# Beaufort Sea Oily Waste Disposal Sites



*final report*

*to*

**Environment Canada**
Conservation and Protection
Environmental Protection
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## PERMITS

This study was carried out under the 1992 Scientific Research License No 12241N issued by the Science Institute of the Northwest Territories on August 6, 1992, and under ILA Right to Access Inuvialuit Lands ILA92TN36, issued July 29, 1992.

## STUDY TEAM

This study was directed by DF Dickins Associates Ltd. of Vancouver with the assistance of Terrain Analysis and Mapping Services Ltd. of Carp, Ontario.

David Dickins managed the study and developed the final short list of potential sites prior to going into the field. Sandra Peters and Phil Langille of Dickins Associates assessed all possible sites for possible conflicts with the different environmental sensitivity criteria. Phil Langille was responsible for reviewing the relevant guidelines and regulations in the United States and Canada concerning oily and/or hazardous waste disposal.

Vern Rampton of Terrain Analysis and Mapping reviewed all possible sites identified in previous reports and suggested a number of new sites in other areas for possible field surveys. Vern was responsible for evaluating the sites from the aspects of geomorphology, suitable storage times (short to longer term), and constraints governing terrestrial overland access.

The field survey team was comprised of David Dickins, Vern Rampton, and David Tilden from Environment Canada, Yellowknife. In addition, Laura Johnson from Environment Canada, and Charles Klengenberg of the Inuvialuit Lands Administration in Tuktoyaktuk participated in a number of the site surveys. David Tilden made a video tape of each site for internal use.

## SUMMARY

Since the start of offshore drilling in the Beaufort Sea over fifteen years ago, there has never been a clear guide to those sites which would be acceptable for the disposal of oily debris collected during the cleanup of a large accidental spill. The recent experiences with processing over 30,000 tons of solid waste in the aftermath to the Valdez spill focused attention on this critical and often overlooked aspect of spill response. Compared with Prince William Sound, the logistics options available in the Beaufort Sea are even more limited by the long distances and short shipping season.

### Scope and Objectives

This project was initiated with the overall goal of recommending a small number of sites which could be considered for some form of pre-approvals to facilitate the process of disposal in the event of an oil spill emergency in the region. In order to achieve this goal the project was divided into two phases.

The specific objectives of Phase 1 were as follows:

1. To further analyze the environmental and physical suitability of disposal sites mapped in the Beaufort Atlas (Dickins et al., 1987) by incorporating the most recent information on land use, and bird habitat;

2. To suggest other disposal locations where practical in coastal areas not already served by the previously identified sites; and

3. To review and summarize recent guidelines (provincial, state, and federal) in both the United States and Canada which pertain to the problem of oily waste disposal.

The objectives of Phase II were twofold: (1) confirm the suitability of short-listed sites identified in the first phase through site investigations; and (2) to discuss the project with community representatives, the Inuvialuit Land Administration, and government agencies to ensure that the concerns of different parties are identified and factored into the final site recommendations.

## Results

Phase I succeeded in reducing the number of potential sites from some 285 sites spread over 25 general areas (identified in the 1979 Hardy report) to a list of approximately 18 sites spread over 8 general areas (some areas had multiple site options). This reduction in site numbers was achieved through a two staged process of elimination:

> **First,** constraints were imposed that no site could fall within a coastal area ranked as high sensitivity in either the 1987 Beaufort Atlas or the 1988 Canadian Wildlife Service evaluation of key areas for birds, in an area designated as Category E by the Mackenzie Delta Beaufort Sea Regional Land Use Planning Commission, or in an area legally designated or proposed as a conservation site by the federal government.
>
> **Second,** the sites left as potential candidates from the sensitivity screening were reviewed for ease of access and duplication (more favourable sites within a few kilometres).

The Phase 1 work also included a comprehensive review of relevant acts and legislation and applicable guidelines and codes which relate to the problem of oily waste disposal (see Appendix A). The existing codes and guidelines available in Canada do not deal adequately with the issue of emergency disposal and storage of oily debris following an accidental spill.

The most useful Canadian efforts in this regard are a 1988 review of on-land sumps for disposal of waste drilling fluids, a 1989 Code of Practice for Used Oil Management. Since the Phase 1 report was produced, the British Columbia Government has released its own draft Disposal Guidelines (July 1992). The best available guides which have been reviewed and accepted can be found in the United States: notably two documents developed concurrently by the Washington State Department of Ecology, and the Oregon Department of Environmental Quality in July 1991. This work, together with practical lessons learned in Prince William Sound, can be used as the basis for future initiatives specific to the Beaufort region.

The Phase II field program successfully visited all of the sites short-listed in Phase I along with several additional sites considered as alternate locations. Table i summarizes the key physical characteristics of sites considered as potential candidates for oily waste storage.

**Conclusions and Recommendations**

With planning and safeguards (e.g., liners and regular monitoring by government agencies and native representatives) it would be possible to store bagged oily debris with no free oil at any of the locations listed in Table i. Depending on the durability of the storage containers, it may be possible to safely store debris for periods in excess of ten years. Any extended storage would be contingent on regular inspections to monitor the condition of the liner material, test soil samples, and check the integrity of the storage bags.

Coastal stability is not a major factor in favouring one site over another. Apart from King Point and North Point which could experience average retreat rates up to 3 m/yr, most sites are relatively stable, losing less than 1 m per year. In the worst case, limiting the proximity of the oily debris to no closer than 200 m from shore would allow for over 30 years of erosion (leaving a 2X safety factor to account for any variations related to global warming).

**Table i**

**Overall Site Summary**

(favoured site at an individual location shown in brackets)

| Location | Ownership | Storage Area $m^2$ | Direct Barge Access+ |
|---|---|---|---|
| Kay Point | Crown++ | 140,000 (120,000 L1-16B) | No |
| King Point | Crown++ | 110,000 | Yes |
| North Head | Crown* | 168,000 | Possible |
| Hadwen Island | Crown | 580,000 | Doubtful |
| Tuft Point | Tuk I.L.A. | 610,000 (190,000 T4-34) | Unknown |
| Cape Dalhousie | Crown | 200,000 | Possible |
| S.E. C. Dalhousie | Crown | 230,000 | Doubtful |
| Johnson Bay | Tuk I.L.A. | 500,000 | Possible |
| Pulsating Pingo | Tuk I.L.A. | 180,000 | Yes |
| Cape Wolki | Tuk I.L.A. | 200,000 | Possible |
| Cy Peck Inlet | Tuk I.L.A. | 55,000 | No |

\+ Note: direct barge access includes considerations of coastal access to the upland site, as well as possibility of "dry ramping" oiled debris directly onto the beach.

++ Management of any development on the Yukon North Slope from the N.W.T. border to the Babbage River must meet the conservation regime established in the North Slope Management Plan (publication pending).

* Discussions are ongoing at time of writing whereby North Head is one possible site being considered for transfer to private ownership in exchange for a " National Pingo Park" near Tuktoyaktuk.

Marine access is only assured at two out of eleven locations (King Point and Pulsating Pingo in Liverpool Bay). Barge landings may be possible at four other sites; in most cases, barges will have to hold several kilometers or more offshore while helicopters shuttle the oily debris to the storage area.

Of the eleven locations selected as possible candidates through the Phase I screening and the Phase II field surveys, six are on Crown lands within the Inuvialuit Settlement Region, and five are within Inuvialuit Private Lands administered by Tuktoyaktuk. Two sites, King Point and Kay Point are within those lands covered by the North Slope Management Plan. Any discussions regarding pre-approvals for oily waste disposal at any Yukon sites must include the Screening Committee.

During meetings in Inuvik, the concept of using existing DEW facilities (including Komakuk Beach within the Northern Yukon National Park) for emergency storage of oily waste was discussed. The general feeling was that it may be more logical to seek approval for an existing (already disturbed site) than to consider using an untouched area. A review of the regulatory issues surrounding the use of DEW sites for this purpose is outside the scope of this study. It is recommended that these sites receive serious consideration in any future work aimed at identifying sites for pre-approval.

The Inuvialuit Lands Administration is interested in having full and active participation in any discussions and will be included in the review process to comment on this report.

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## 1.0 BACKGROUND AND OBJECTIVES

The need for an improved pre-spill screening of oily waste disposal sites surfaced during the recent Environmental Impact Review Board hearings into Gulf's Kulluk drilling application (1990-92). Subsequent recommendations of the Beaufort Sea Steering Committee confirmed the inadequacy of the existing information base and the need for further investigation.

Sites which could potentially be used for storage of oily debris recovered following an oil spill in the Beaufort Sea were mapped in the Beaufort Sea Atlas (Dickins et al., 1987) using material originally developed by Hardy and Associates (1979). There was no opportunity during the preparation of the Beaufort Sea Atlas to undertake any new analysis or field visits, or community consultations to confirm individual site suitability (the Inuvik workshop held as part of the Atlas preparation dealt with issues of coastal sensitivities to direct oiling rather than disposal).

The overall objective of this study was to arrive at a short list of potential sites which would be acceptable for medium and longer term storage of oily wastes (typically a few to ten years) recovered during the cleanup of a marine oil spill in the Beaufort Sea. Section 4 discusses the criteria which were used as a measure of acceptability in assessing potential sites.

The specific objectives of Phase 1, the subject of this report, were as follows:

1. To further analyze the environmental and physical suitability of disposal sites mapped in the Beaufort Atlas by using the most recent information on land use, and bird habitat;

2. To suggest other disposal locations, where practical, in coastal areas not already served by the previous distribution of sites; and

3. To review and summarize recent guidelines (provincial, state, and federal) in both the United States and Canada which pertain to the problem of oily waste disposal (see Appendix A).

The objectives of Phase II were twofold: (1) confirm the suitability of short-listed sites identified in the first phase through on-site investigations; and (2) to discuss the project with community representatives, the Inuvialuit Land Administration, and government agencies to ensure that the concerns of different parties in the N.W.T and the Yukon are identified and factored into any final site recommendations which follow this study.

The overall aim is to use the results of this study as a basis for discussions to gain provisional pre-approval (by regulatory agencies, the I.L.A., local residents and other concerned parties) for a number of sites which could be used in the event of a future oil spill emergency in the region.

## 20 SCOPE OF WORK

This study includes the geographic area displayed in the 1987 Beaufort Sea Atlas (Dickins et al., 1987) from Demarcation Point in the west to Baillie Islands in the east.

The Beaufort Atlas plots sites as being either "permanent" or "temporary". Current disposal practices avoid such a black and white determination. It can be argued that all sites should be considered temporary: some sites more so than others. This study focuses on those sites which may be suitable for oily waste disposal over time periods of several years to more than a decade. No distinction is made in this report between "temporary" and "permanent".

It is assumed that almost any location could be used for temporary emergency holding of oily debris for periods of days to months (pending other transport arrangements to an approved facility); no attempt was made in this study to assess the suitability of specific coastal areas for such short-term use.

The main goal of the Phase I analysis was to arrive at a small number of potential sites which could be examined within a one week field program. The criteria used to eliminate locations from further consideration were

extremely conservative; it was felt that such an approach was realistic given high level of public concern regarding any issue concerning oil spill cleanup and disposal.

The Phase II field program consisted of a ground level examination of potential sites; pits were dug to document soil conditions and the depth of the active layer at different locations. At the same time, an experienced geologist noted the surface features, and nearby coastal stability to judge the overall suitability of the site in terms of drainage and potential for losses from the site. Aerial photographs were marked at the site in terms of the most promising areas, and possible shore access points (where favoured by shoreline topography). A set of ground level photographs and aerial obliques was obtained at each site. In addition, a video tape was recorded on the ground and in the air; this tape can be viewed by contacting the Yellowknife office of Environment Canada (D. Tilden).

The field component of this project allowed a period of only a few hours at each site. Final acceptance and pre-approval of any sites described in this report may require certain conditions on overland access, and minimum setbacks from the shoreline to guard against the effects of bank erosion.

## 3.0 DATA SOURCES

The Environmental Atlas for Beaufort Sea Oil Spill Response (Dickins et al., 1987) formed the basis for evaluating the environmental sensitivity of sites originally identified by Hardy and Associates (1979); the Atlas information was checked against and supplemented by more recent sources wherever possible.

The following sources of information were used to complete Phase I of this study:

- Geomorphology
  - "Environmental Atlas for Beaufort Sea Oil Spill Response" (Dickins et al., 1987) - initial selection of feasible sites
  - "Oiled Debris Disposal and Storage Sites Beaufort Sea Coast" (R.M. Hardy & Associates Ltd., 1979) - the original basis for sites mapped in the atlas (re-examined in this study)
  - review of surficial geology maps and reports pertaining to the area (Rampton 1970, 1972, 1974, 1979a,b,c, 1982, 1988)
- Coastal Sensitivity
  - "Environmental Atlas for Beaufort Sea Oil Spill Response" (Dickins et al., 1987) - overall sensitivity rankings
  - "A Community-Based Regional Land Use Plan for the Mackenzie Delta-Beaufort Sea Region" (Mackenzie..., 1991) - map showing proposed land classifications
  - "Key Areas for Birds in Coastal Regions of the Canadian Beaufort Sea" (Alexander et al., 1988) from the Canadian Wildlife Service - used to re-evaluate those areas which are highly used by birds during spring, summer and fall (this information was not available when the original Beaufort Atlas sensitivity rankings were established)

The N.W.T. Remote Sensing Centre was contacted; it was determined that they hold no imagery or photos which would be of value to the project.

## 4.0 INITIAL SITE SELECTION: PHASE 1

Prior to evaluating sites against specific criteria, the original Hardy 1979 report, with maps and aerial photographs, was reviewed to provide a critical appraisal of the methodology and to understand the rationale used in the original selection process. Based on this review the study team felt comfortable in using the original Hardy selections as a valid starting point.

### 4.1 Criteria

The following sections describe the process of developing a series of criteria related to geomorphology, access, and environmental sensitivity against which to either accept a particular site on a provisional basis (pending further field assessment) or to reject a site from further consideration.

#### 4.1.1 Coastal Sensitivity

Three main sources were combined to identify those sites falling in highly sensitive environmental areas: the original Beaufort Sea Atlas, the Mackenzie Delta - Beaufort Sea Regional Land Use Planning Commission map of land management categories, and the Canadian Wildlife Service maps of bird migration and nesting patterns.

#### 4.1.2 Beaufort Sea Atlas Sensitivity Designations

The sensitivity ranking system used in the 1987 Beaufort Sea atlas was developed to describe the relative sensitivity of shoreline areas to the effects of marine oil spills. The original ranking system was based on a total of 20 individual environmental elements grouped in three main categories: (1) human use; (2) biological sensitivity; and (3) shore zone oil residence. The rationale for inclusion and ranking of the individual elements in the Atlas was based on:

1. A review of literature regarding the sensitivity and vulnerability of resources to the effects of oil
2. Resources identified through the Beaufort Environmental Monitoring Project (DIAND, 1985) as being the highest profile in the region

3. Research on the fate and persistence of oil in cold, ice-infested water and in northern coastal environments

4. The results of a workshop conducted in Inuvik on January 14, 1987, to determine the use of the land and renewable resources by residents of the region (attended by men and women from Old Crow, Aklavik, Inuvik and Tuktoyaktuk)

The sensitivity of a specific shoreline area was determined by summing the Assigned Values for all environmental elements which apply in a particular area. Finally, the ranking of shoreline areas was simplified to three degrees of sensitivity (LOW, MODERATE, AND HIGH). A full description of the system and the rationale applied to each element is contained in Dickins et al., (1987)).

### 4.1.3 Beaufort Sea Regional Land Use Planning Commission/I.L.A

The land jurisdictions and land sensitivity for each proposed disposal site (not considered in the original Beaufort Sea atlas) were identified based the geographic divisions of administrative responsibility. The lands in the Beaufort Sea coastal region are either administered by the Department of Northern and Indian Affairs (DIAND) or the Inuvialuit Land Administration (ILA). If a disposal site is located on "crown" controlled lands the site would require waste disposal permits under the Land Use Permit system of DIAND. In addition, any site development proposed for the Yukon North Slope must meet the terms of the North Slope Management Plan (in press at the time of writing).

Approval and permits for the "ILA-Tuktoyaktuk" designated lands would have to be obtained directly from the people of Tuktoyaktuk. The sensitivity of Inuvialuit lands (as designated by the Mackenzie

Delta - Beaufort Sea Regional Land Use Planning Commission, 1991) was incorporated as one of the criteria in accepting or rejecting specific sites at this stage.

The land management categories defined by the Land Use Planning Commission are described below:

Category A Lands:
There are no specific sites mapped by the Commission in this category. The "A" designation refers to lands where there are no known significant and sensitive cultural and renewable resources.

Category B Sites:
Lands where there are cultural or renewable resources of some significance and sensitivity, but where terms and conditions associated with permits and lease shall ensure the conservation of these resources.

Category C Sites:
Lands where cultural or renewable resources are of particular significance and sensitivity during specific times of the year. These lands shall be managed so as to guarantee the conservation of the resources.

Category D Sites:
Lands where cultural or renewable resources are of particular significance and sensitivity throughout the year. As with category C lands, these lands shall be managed so as to guarantee the conservation of the resources.

Category E Sites:
Lands where cultural or renewable resources are of extreme significance and sensitivity. There shall be no development on these lands. These lands shall be managed to guarantee absolutely no damage or disruption. This category offers the highest degree of protection, short of legal designation.

*Note: on category E lands identified by the Department of Fisheries and Oceans, and the Fisheries Joint Management Committee (FJMC), some development may be allowed under certain circumstances (see the Land Use Plan).*

Legally Designated Conservation Sites - Existing and Proposed Sites

Legislated and proposed national parks, Canadian landmarks, territorial parks, bird sanctuaries, and International Biological Program sites, which should be candidates for ecological reserves.

Any potential disposal sites which are located on lands with a designation of "E" or "Legally Designated Conservation Sites" were removed from the proposed list of sites during Phase I of this study. A subsequent meeting with the Canadian Parks Service and representatives of native hunters and trappers associations revealed that favourable consideration could be given to designating abandoned DEW sites within park boundaries as logical, safe storage areas for oily waste.

Regardless of their land use designation, all potential sites will require further investigation and local consultation before reaching a final decision regarding their acceptability (Section 6.0).

### 4.1.4 CWS Bird Habitat Mapping

At the time of production of the Beaufort Sea Environmental Atlas there were few sources of information which identified highly sensitive areas with respect to sea and shore birds. A subsequent report produced by the Canadian Wildlife Service (Alexander et al., 1988) identifies and maps areas of high, variable, moderate and low use by birds during three different periods in the summer: early June to mid-July, mid-July to mid-August, and mid-August to the end of September. This document is still the most complete and comprehensive mapped survey of bird habitat and sensitivity in this region.

The CWS report was used in this study as one of the sensitivity criteria to confirm which coastal areas are highly sensitive to birds. If the proposed disposal site fell in an area rated "high" for any period of time during the year according the CWS designation it was removed from the list of potential sites. Any sites in an area rated as "variable"

("high" in some years) were flagged on the short list; these sites could be removed from further consideration in an actual emergency depending on biological considerations.

### 4.1.5 Geomorphology

Sites were also restricted according to geomorphic and geotechnical guidelines set out by R.M. Hardy and Associates Ltd. (1979). These guidelines were as follows:

- sites to be inland of maximum storm surge;
- sites to be as close to the coast as possible to limit terrain disturbance from access activities;
- sites to be on level or gently sloping terrain and to be some distance from the toe or crest of significant slopes;
- sites to avoid ice-cored topography where possible;
- sites to avoid floodplains and the high water mark of lakes;
- sites to avoid ponded water and poorly drained sites such as sedge meadows where possible; and
- sites to avoid recently drained lakes, taliks, and large icing zones.

The feasibility of areas along the coast which were likely to meet the required guidelines were evaluated through a review of surficial geology maps and reports pertaining to the area (Rampton 1970, 1972, 1974, 1979a,b,c, 1982, 1988). The exact sites were located through air photo interpretation.

In assessing the site locations prior to the field survey, a three-tiered classification was initially attempted to provide some indication as to which sites would be more suitable for different periods of storage: 2 to 6 years; 5 to 12 years; and >10 years.

Considerations of terrestrial access overland were applied wherever possible as part of the overall geomorphological criteria in the initial screening process. The final selection of short-listed sites (after taking sensitivity into account) was further reviewed in terms of expected degree of difficulty in terms of direct marine access (see below).

Storage sites suitable shorter periods were considered as those which could be easily accessed from areas of heavy oiling during the summer with light equipment. It was envisaged that these sites would be immediately adjacent to the coast to reduce terrain damage from repeated travel to and from site. The constraints imposed on Beaufort clean-up by the short season will result in a period of intense logistical activity followed by a lull until the following spring. It is considered essential that even these shorter term sites be well above levels of storm surges or coastal retreat over a period of 2 to 6 years. Oily debris at these sites would probably be stored in a stockpile on an impermeable liner. To reduce terrain damage and disturbance to local biota, little or no native material would be utilized.

Longer term sites were initially located along the coast at intervals of 5 to 40 miles. Again, material would likely be stockpiled on a liner.

Sites suitable for more extended storage were originally located at 30 to 60 mile intervals, favouring operating or abandoned DEW Line sites. Storage at these locations would probably use existing gravel pads.

A number of conditions could be present at each site that may require mitigation or monitoring for successful storage of oil waste. Examples of such conditions include: the amount of surface water seeping through the active layer across the site; the presence of seasonal standing water or marshy conditions during melt season; the presence of ice wedges; ice-wedge polygons and their effect on the drainage; and the presence of thin peat and icy fine-grained sediments underlying the site.

### 4.1.6 Marine Access

The previous section identified concerns associated with land forms, surficial geology, and slopes which could curtail overland access. Additional information related to air and marine access was noted for each site:

- distance to the nearest feasible barge landing site identified in the Beaufort Sea Atlas (Dickins et al., 1987) - in cases where no direct landing site was identified, best judgment was used by reviewing comments from the Sailing Directions: Arctic Canada (Fisheries and Oceans, 1986), and considering the coastal type, channel widths and presence of shoal areas.

- distance to nearest airstrip - essentially Tuktoyaktuk or a DEW site whichever is closer. Floatplane access may be possible in the summer at some sites and offstrip landings could be performed under ideal conditions at certain locations (this form of access, not considered reliable enough for routine access, was not counted in measuring the distances). It was assumed that all sites are accessible by helicopter.

- average duration of open water season (from information mapped in the Beaufort atlas) - ranging from 12 to 16 weeks.

Given the almost total lack of nearshore bathymetric data in many areas, and changing seabed contours due to rapid infilling rates, it proved very difficult to gauge the potential for barge landing at most of the sites. As discussed at the community meeting in Inuvik following the field program (Section 6) this uncertainty may not be a serious problem given the likely reliance on extensive helicopter support to sling oily debris from barges to the shore sites; in that case it makes little difference whether the barge is able to drop a ramp directly onto the beach (rare) or is forced by shallow water to anchor a few miles off.

The results of the preliminary Phase I access review, together with additional impressions gained from the field surveys are incorporated in the individual site descriptions in Appendix C.

## 4.2 Short List of Potential Sites: Phase 1

Based on the results of the site selection criteria in the three broad categories of sensitivity and geomorphology, a short list of recommended sites was prepared as the basis for further field investigation and local consultation (Table 1). The aim was to arrive at a reasonable number of promising sites which provide a fairly even geographic distribution from west to east.

Appendix B contains detailed location maps together with tables summarizing the sensitivity criteria of all of the sites reviewed in Phase I of the study (including the sites listed in Table 1).

**Table 1**
**Recommended Short-list of Possible Oily Waste Disposal Sites**

| | | | |
|---|---|---|---|
| T2-6 | King Point | L1-16 | Kay Point |
| T3-15 or 14 | North Head | L3-14 or 15 | North Head |
| T4-33 | Tuft Point | L4-33 or 34 | Tuft Point |
| | | L4-60 | Cape Dalhousie |
| | | DR-2 | Johnson Bay |
| | | DR-3 | Pulsating Pingo |
| T7-31 | Cape Wolki | L7-31 | Cape Wolki |
| T7-14 or 15 | Cy Peck Inlet | L7-14 or 15 | Cy Peck Inlet |

This short list identifies six general locations between Kay Point on the Yukon coast and Cape Bathurst for further evaluation during the summer of 1992. Additional sites at Hadwen Island (North Point) and Cape Dalhousie were added during the field survey (see Section 5.0).

Note: the vertical line in Table 1 separates sites considered suitable for temporary (T) storage from those considered suitable for longer term storage (L) in the original 1979 report by Hardy and Associates. In most cases a (T) site was accompanied by an (L) designated site nearby (less than 2 km inland). These distinctions were not continued in this study although the original Hardy site designators are retained for ease of cross-referencing with the original work.

## 5.0 SUMMARY OF FIELD SURVEY RESULTS

The study team together with the client visited all of the short-listed sites indicated in Table 1 together with several others (Hadwen Island DR-4, and Southeast of Cape Dalhousie DR-1).

Each site was documented with field notes, and photographs. The results are reported in Appendix C, and summarized here according to relative site suitability. Figures 1 and 2 show the general site locations. Two types of site identifiers are used: (1) sites previously identified by Hardy and Associates in 1979 have their original designator e.g., L7-31; (2) new sites surveyed in this project have a designator DR-1, 2 etc.

**Table 2**
**Field Survey Sites**
(use also as general key to Figures 1 and 2)

| Site No. Fig. 1&2 | Geographic Name | Site Designator |
|---|---|---|
| 1. | Kay Point | L1-16 |
| 2. | King Point | T2-6 |
| 3. | North Head | L3-14 & 15, T3-14 |
| 4. | Hadwen Island | DR-4 |
| 5. | Tuft Point | T4-33 & 34, L4-33 &34 |
| 6. | Cape Dalhousie | L4-60 |
| 7. | S.E. of Cape Dalhousie | DR-1 |
| 8. | Johnson Bay | DR-2 |
| 9. | Pulsating Pingo | DR-3 |
| 10. | Cy Peck Inlet | T7-14 |
| 11. | Cape Wolki | T7-31 |

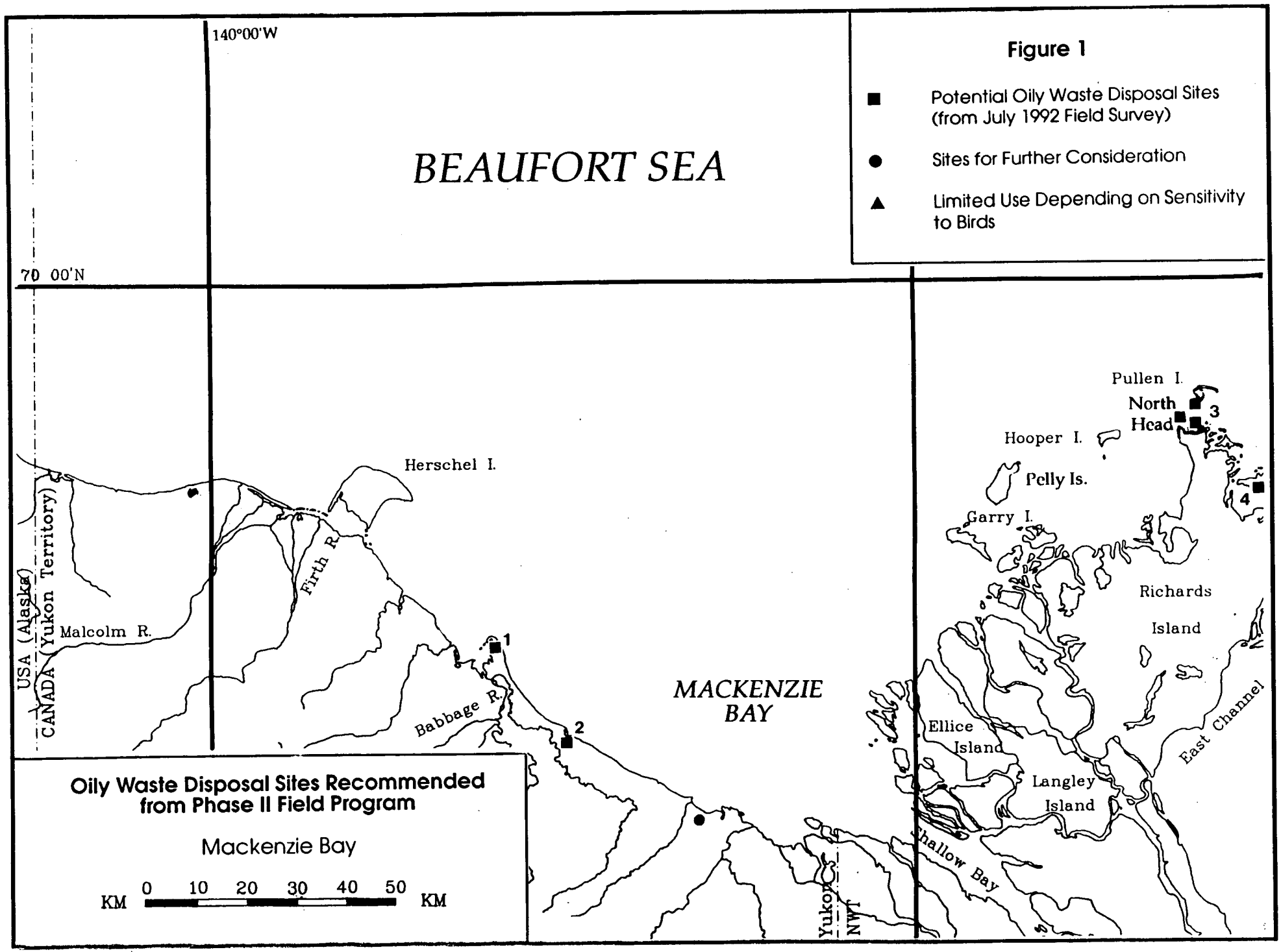
Figure 1
Potential Oily Waste Disposal Sites (from July 1992 Field Survey)
Sites for Further Consideration
Limited Use Depending on Sensitivity to Birds
140°00'W
70 00'N
BEAUFORT SEA
Herschel I.
USA (Alaska)
CANADA (Yukon Territory)
Malcolm R.
Firth R.
Babbage R.
1
2
MACKENZIE BAY
Pullen I.
North Head
3
Hooper I.
Pelly Is.
4
Garry I.
Richards Island
Ellice Island
Langley Island
East Channel
Shallow Bay
Yukon
NWT
Oily Waste Disposal Sites Recommended from Phase II Field Program
Mackenzie Bay
KM 0 10 20 30 40 50 KM

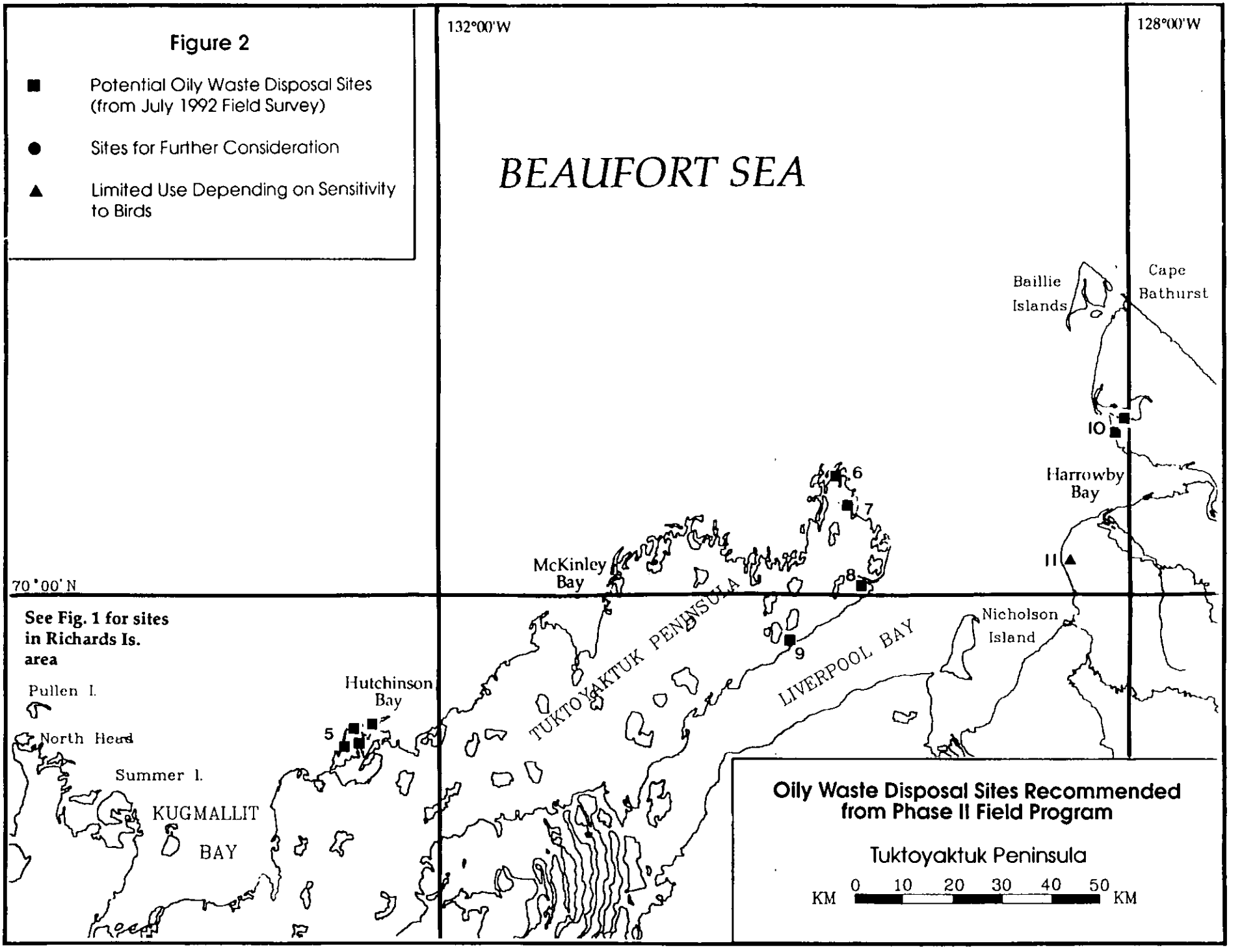
Figure 2
Potential Oily Waste Disposal Sites (from July 1992 Field Survey)
Sites for Further Consideration
Limited Use Depending on Sensitivity to Birds
132°00'W
128°00'W
BEAUFORT SEA
Baillie Islands
Cape Bathurst
Harrowby Bay
McKinley Bay
TUKTOYAKTUK PENINSULA
LIVERPOOL BAY
Nicholson Island
70°00'N
See Fig. 1 for sites in Richards Is. area
Pullen I.
North Head
Summer I.
KUGMALLIT BAY
Hutchinson Bay
5
6
7
8
9
10
11
Oily Waste Disposal Sites Recommended from Phase II Field Program
Tuktoyaktuk Peninsula
KM 0 10 20 30 40 50 KM

Table 3 summarizes the sites in terms of active layer depth, surface soils, coastal retreat, and drainage (from observations in field).

**Table 3**
**Summary of Key Physical Characteristics**
(in case of multiple sites at one location, the preferred or representative site is noted)

| Location | Drainage/ Terrain | Surface Soils | Active Layer | Coastal Retreat |
|---|---|---|---|---|
| Kay Point | moderate/flat | thin peat over silt | 20 cm | 1 m/yr |
| King Point | moderate/flat | thin peat over silt | 35 cm | 2.4 to 3.1 m/yr |
| North Head | good/flat | silty fine sand | 35 cm | 2.2 m/yr |
| Hadwen Island | good/gentle rolling | thin peat over sand | 60 to 90 cm | ~0 to 0.7 m/yr stable |
| Tuft Point | moderate/ gentle slope | thin organic rich over silt | 55 cm | ~0.2 m/yr stable |
| Cape Dalhousie | good to mod. flat | thin peat over sand | 70 cm | ~ 0.5 m/yr active |
| S.E. C. Dalhousie | moderate/ gentle rolling | med. sand + peat | 70 cm | low |
| Johnson Bay | good to mod. flat | thin peat over sand | 60 to 70 cm | 0 to 0.8 m/yr |
| Pulsating Pingo | good/ gentle slope | thin peat over sand | 65 cm | ~ 0.8 m/yr |
| Cy Peck Inlet | poor to mod. flat | thin silt over sand | 90 cm | not known |
| Cape Wolki | moderate/ gentle slope | thin organics over silt | 60 cm | stable barrier beach |

Table 4 summarizes the sites by geographic location in terms of storage area (order of magnitude estimate), potential for marine/overland access suitability, and regulatory/jurisdictional considerations (e.g., land ownership, environmental sensitivity).

Where multiple sites exist within a small area (e.g., North Head, Tuft Point), the cumulative total storage area is included; the favoured site in terms of surface conditions and coastal access is noted separately with its accompanying code. It should be noted that the storage areas are a guide only to those sites surveyed in this study. Larger or alternate areas could be easily identified in the vicinity of many of the sites through more extensive air photo analysis and ground surveys.

**Table 4**
**Overall Site Summary**
(favoured site at an individual location shown in brackets)

| Location | Ownership | Storage Area $m^2$ | Direct Barge Access+ |
|---|---|---|---|
| Kay Point | Crown++ | 140,000 (120,000 L1-16B) | No |
| King Point | Crown++ | 110,000 | Yes |
| North Head | Crown* | 168,000 | Possible |
| Hadwen Island | Crown | 580,000 | Doubtful |
| Tuft Point | Tuk I.L.A. | 610,000 (190,000 T4-34) | Unknown |
| Cape Dalhousie | Crown | 200,000 | Possible |
| S.E. C. Dalhousie | Crown | 230,000 | Doubtful |
| Johnson Bay | Tuk I.L.A. | 500,000 | Possible |
| Pulsating Pingo | Tuk I.L.A. | 180,000 | Yes |
| Cape Wolki | Tuk I.L.A. | 200,000 | Possible |
| Cy Peck Inlet | Tuk I.L.A. | 55,000 | No |

\+ Note: direct barge access includes considerations of coastal access to the upland site, as well as possibility of "dry ramping" oiled debris directly onto the beach.

++ Management of any development on the Yukon North Slope from the N.W.T. border to the Babbage River must meet the conservation regime established in the North Slope Management Plan (publication pending).

* Discussions are ongoing at time of writing whereby North Head is one possible site being considered for transfer to private ownership in exchange for a " National Pingo Park" near Tuktoyaktuk.

## 6.0 COMMUNITY/AGENCY CONSULTATIONS: PHASE II

Two meetings were held during August 1992 in the N.W.T. to discuss the objectives of this project and the results of the field program with local native representatives in the Beaufort Sea as well as federal and territorial agencies. Appendix D lists the participants in both meetings, the first on August 13, 1992 in Inuvik and the second on August 17, 1992 in Yellowknife. At the time of writing of this report an additional meeting was planned for Whitehorse early in 1993 to discuss the project with representatives of the Yukon Government Department of Renewable Resources, and the regional offices of Indian and Northern Affairs Canada and Environment Canada.

Appendix D lists the participants at each of the N.W.T. meetings. The following discussion outlines the key points raised during the discussions held in Inuvik and Yellowknife.

An overview of a typical oily waste logistics operation was presented. It is expected that work crews operating from shorebased temporary camps or floating offshore barge camps would clean different beach sections and bag oily debris for temporary storage above the normal high water line. At this point the bags would probably be standard heavy duty trash bags used commonly in many other beach cleaning operations. The debris itself would likely have a very low oil content (in the order of a few percent or less) and may be comprised of a mix of lightly oiled sand and fine gravel, oiled driftwood fragments (larger pieces would be burned in situ), and mixed organic material present on many beaches with slumping cliffs. Beaches with a thick coating of oil would be cleaned through some form of flushing and recovery nearshore with skimmers, direct suction (in the case of discrete pools), and possibly some selective mechanical removal in areas where heavy equipment could be used effectively without causing unacceptable damage.

One or more barge/helicopter combinations would be dedicated to moving along the beach to collect and rebag the trash bags into more durable synthetic nylon weave "supersacs". As used in the mining industry for shipping concentrate ore, these sacs are helicopter transportable and can carry in the order of 3,000 pounds. Barges loaded with these sacs would be moved as close

as feasible to the nearest acceptable storage site and the bags either slung inland by helicopter or moved directly onto the beach and inland with high floatation vehicles (e.g., Rollagons). The number of sites where direct overland logistics would be possible is very limited. The bulk of the work would likely be carried out by multiple helicopters slinging over several miles.

Site preparation could be limited to a double liner to receive the bags and prevent any possibility of soil contamination. If there was a concern about possible runoff into nearby lakes or the ocean, borrow material could be brought in to construct a dike. In most cases, the waste bags can be located sufficiently far enough from any sensitive area to satisfy any concerns about runoff or coastal stability. It should be pointed out that none of the sites or methods discussed in this report are suitable for dealing with liquid oily waste or free oil.

Participants at the meetings were encouraged to view the current program as a first step which could lead to some form of pre-approval for particular sites (with possible constraints imposed on the composition and volume of debris, monitoring schedule, and timing of access). Any form of final approval will require a series of discussions and agreements between many different agencies and organizations. The current lull in oil industry operations in the region provides an ideal opportunity to prepare for future emergencies without the pressure of active development plans.

It was agreed that the list of possible sites contained in this report needs to be reviewed by the communities of Aklavik, Inuvik, and Tukyoyaktuk. It is expected that adjustments may be made to this list taking into account specific local concerns. The revised list arrived at through this process can then form the basis for further discussions leading to some form of interagency agreement (including the federal and territorial governments, the I.L.A., and the H.T.C. in each community).

The Canadian Parks Service suggested that serious consideration be given to identifying one or more of the DEW sites as logical repositories for oily waste in an emergency. Two examples of sites which already have considerable

infrastructure in the way of prepared pads, roads, barge landings etc. are Komakuk Beach and Shingle Point. Figures 3 and 4 show aerial views taken of Shingle Point during the 1992 field program. The concept of using a site with existing facilities makes good sense. DEW sites should be considered in any follow-on to this study.

# APPENDIX B

Sensitivity Evaluation of Potential Disposal Sites, and Maps Showing their Locations (Prior to the Field Survey)


**Figure 3:** Overall view of shoreline south of barge landing at Shingle Point. Note prepared pad on high ground (not in use) and runway. North Warning Site (DEW) in background


**Figure 4:** Overall view of infrastructure (pads, gravel borrow pits, roads) at the marine landing site for barges at Shingle Point

## 7.0 CONCLUSIONS AND RECOMMENDATIONS

With planning and safeguards (e.g., liners and regular monitoring) it would be possible to store bagged oily debris with low oil content at any of the locations listed in Table 2 for a minimum period of two to ten years. Depending on the durability of the storage containers, it may be possible to safely store debris for a much longer period. Any extended storage would be contingent on regular inspections to monitor the condition of the liner material, test soil samples, and check the integrity of the storage bags.

This project provides an initial screening of candidate locations based on environmental sensitivity and social concerns, and includes a preliminary field investigation to confirm the potential suitability of selected sites. Further work may be required to design the most effective remedial measures to protect an individual site (including preparation and monitoring by native organizations and government agencies). These measures will depend on such factors as: the amount of surface water seeping through the active layer across the site; the presence of seasonal standing water or marshy conditions during melt season; the presence of ice wedges, ice-wedge polygons and their effect on the drainage; and the presence of thin peat and icy fine-grained sediments underlying the site.

Coastal stability is not a major factor in favouring one site over another. Apart from King Point and North Point which could experience average retreat rates up to 3 m/yr, most sites are relatively stable, losing less than 1 m per year. In the worst case, limiting the proximity of the oily debris to no closer than 200 m from shore would allow for over 30 years of erosion (leaving a 2X safety factor to account for any variations related to global warming).

Marine access is only assured at two out of eleven locations (King Point and Pulsating Pingo in Liverpool Bay). Barge landings may be possible at four other sites but in most cases, barges will have to hold several kilometers or more offshore while helicopters shuttle the oily debris to the storage area (the

other alternative of slinging debris directly from the oiled beach to the storage site would not be economically practical except where a major spill occurred in close proximity to a site itself).

Of the eleven locations selected as possible candidates through the Phase I screening and the Phase II field surveys, six are on Crown lands within the Inuvialuit Settlement Region, and five are within Inuvialuit Private Lands administered by Tuktoyaktuk. Two sites, King Point and Kay Point are within those lands covered by the North Slope Management Plan. Any discussions regarding pre-approvals for oily waste disposal at either of these sites must include the Screening Committee (applies also to the Shingle Point DEW site - see comment below).

During meetings in Inuvik, the concept of using existing DEW facilities for emergency storage of oily waste was discussed (including Komakuk Beach within the Northern Yukon National Park). The rationale behind this idea centres on the logic of seeking approval for an existing (already disturbed site) rather than using an untouched wilderness area. A review of the regulatory issues surrounding the use of DEW sites for the purpose of emergency oily waste storage is outside the scope of this study. It is recommended that these sites receive serious consideration in any future work aimed at identifying any sites for pre-approval in the Beaufort Sea region.

The Inuvialuit Lands Administration is interested in having full and active participation in any discussions and will be included in the review process to comment on this report.

The review of legislation and guidelines in the United States and Canada revealed that there is little or no information available in Canada which provides a useful guide to the specific problems of oily waste disposal in an emergency situation (particularly where high volumes of mixed solid and liquid debris are encountered). Perhaps the most relevant document oriented towards northern issues of oily waste disposal is an evaluation of handling and disposal of waste drilling fluids from on-land sumps in the N.W.T. and the Yukon (ESRF, 1988). The recently released draft disposal guidelines for

British Columbia contains a useful categorization scheme to discriminate between different forms of debris (this document was issued too late to be reviewed during Phase I of this study).

In the United States, the awareness and knowledge of the massive problems associated with oily waste disposal following a large spill took a quantum leap in the aftermath of the *Valdez* incident. As a result, at least two states (Oregon and Washington) have recently released comprehensive and detailed guidelines on oily waste disposal; much of this work and the lessons learned during the *Valdez* disposal operation can be used to improve the state of preparedness in the Beaufort region.

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# APPENDIX A

Review of Relevant Guidelines

## REVIEW OF RELEVANT GUIDELINES AND REGULATIONS

It was recognized at the outset of this review that many of the existing guidelines and documents concerning landfill of hazardous wastes are either not relevant to the problem of oily debris disposal during an oil spill emergency, or are intended for sites which are already contaminated to some degree.

The aim of this review was to provide a concise summary of any sections of applicable guidelines (e.g., National Guidelines for Landfilling of Hazardous Waste, and Code of Practice for Used Oil Management) which could affect any future initiatives to gain provisional regulatory approvals for oily waste disposal sites.

Many of the existing and proposed regulations governing the selection and management of disposal sites in Canada were developed with southern problems in mind, and are not entirely relevant to the particular concerns of oil debris storage/disposal in the North. Efforts were made here to review any recent state and federal American initiatives which pertained more directly to oil spill response and disposal than available Canadian standards (e.g. as an outcome of the far reaching OPA 90 legislation now in process of being implemented).

An important portion of the review focused on extracting information from practical experiences documented with regard to disposal activities during recent spill cleanup operations (e.g. *Exxon Valdez*).

## A.1 Review of Applicable Canadian Legislation

The major federal and territorial legislation used to regulate the transportation, handling, storage and disposal of waste are listed below.

**Arctic Waters Pollution Prevention Act**
- Arctic Shipping Pollution Prevention Regulations
- Arctic Water Pollution Prevention Regulations

**Canadian Environmental Protection Act**
- Ocean Dumping Control Regulations

**Canada Shipping Act**
- Air Pollution Regulations
- Dangerous Goods Regulations
- Garbage Pollution Prevention Regulations
- Oil Pollution Prevention Regulations
- Pollutant Substances Regulations

**Environmental Protection Act (NWT)**

**Environmental Rights Act (NWT)**

**Fisheries Act**

**Government Organization Act**

**Hazardous Materials Information Review Act**

**Hazardous Products Act**
- Controlled Products Regulations
- Hazardous Materials Information Review Regulations
- Ingredient Disclosure List

**Migratory Birds Convention Act and Regulations**

**Northern Inland Waters Act**
- Northern Inland Waters Regulations

**Occupational Safety and Health (Federal and Territorial)**

**Oil and Gas Production and Conservation Act**
- Canada Oil and Gas Drilling Regulations
- Canada Oil and Gas Production and Conservation Regulations
- Oil and Gas Spills and Debris Liability Regulations

**Public Health Ordinance (Yukon)**

**Public Lands Grants Act**

**Territorial Lands Act**

Territorial Land Use Regulations

**Transportation of Dangerous Goods Act**

Transportation of Dangerous Goods Regulations (Federal & Territorial)

**Yukon Environment Act**

While the federal government does not have comprehensive legislation in place dealing specifically with waste management, there are several legislative mechanisms which prescribe how wastes must be handled. The pertinent Acts and relevant regulations listed above are explained in detail below:

**Arctic Waters Pollution Prevention Act**

The purpose of this Act is to maintain the quality of Arctic Waters through the regulation of waste disposal into them. The Act applies to all Arctic Waters, as defined by the Act, and to the mainland or islands which constitute the Arctic Ocean Watershed.

Section (4(1)) of the Act prohibits the deposit of waste on any area of the mainland or Arctic Islands where there is a possibility of it entering salt water.

The Arctic Waters Pollution Prevention Regulations allows for the deposition of Industrial waste in Arctic Waters under terms authorized by the Oil and Gas Production and Conservation Act, Territorial Lands Act, or in the Public Lands Grants Act. Domestic waste may be discharged to Arctic Waters under conditions authorized by the N.W.T. Environmental Protection Act and/or the Yukon Public Health Ordinance. The Arctic Waters Pollution Prevention Regulations are administered jointly by The Department of Indian Affairs and Northern Development (DIAND) and the Canadian Coast Guard (CCG). The CCG administers all shipping related activities and DIAND handles all non-shipping related activities.

**Canadian Environmental Protection Act (CEPA)**

The Act was passed into law on June 30, 1988. It is a broad all encompassing Act that deals with environmental protection at all levels. Environmental legislation existing prior to this Act has been incorporated into CEPA.

The Canadian Environmental Protection Act has a number of elements. Firstly, it provides Environment Canada the authority to control the introduction into Canadian commerce of substances that are new to Canada. In addition it provides authority to obtain information and to require testing of both new substances and substances already existing in Canadian commerce. It also has provisions to control all aspects of the life cycle of toxic substances from their development, manufacture or importation to transportation, storage, use, their release into the environment and their ultimate disposal as waste.

Environment Canada is given authority to regulate fuels and components of fuels. Emissions, effluents, waste handling and disposal practices of federal departments, boards and agencies and Crown corporation are also controlled. The creation of guidelines and codes for environmentally sound practices as well as objectives setting desirable levels of environmental quality are covered under this legislation.

The federal Clean Air Act which provided for the control of air pollution has been rolled over into the new CEPA legislation. Regulations and Guidelines may be established under this legislation controlling the quantities and concentrations of air contaminants that may be emitted from stationary sources.

The only Guideline presently in place that is of concern to northern waste management issues is the Guideline for package incinerators. This guideline provides information on acceptable levels of particulate and smoke emissions. In addition the methods of testing incinerators for burning efficiency are outlined.

The Ocean Dumping Control Act which used to regulate the dumping of materials into the sea has been incorporated into CEPA as Part VI. It details what substances are prohibited from being discharged and other restricted substances. The process for applying for an Ocean Dumping Permit is also outlined.

The Ocean Dumping Control Regulations define the dumping limits for certain substances and describe the reporting process that must be followed after a dumping has occurred. Crude oil, and it's wastes, petroleum products, residues and any mixture of these are prohibited substances for which an ocean dumping permit can not be granted.

Part VI of CEPA and the Regulations do not apply to any disposal into the ocean that is incidental to or derived from the normal operations of a ship, or offshore oil and gas exploration.

**Canada Shipping Act**

This act regulates all aspects of shipping for both Canadian vessels and foreign ships operating in Canadian waters. The Act is enforced by the Canadian Coast Guard and contains several regulations relating to the storage, handling and disposal of wastes generated by ships. A number of these regulations are superseded north of 60° for waters that have been included within a Shipping Safety Control Zone under the Arctic Waters Pollution Prevention Act and Regulations. The Air Pollution Regulations and the Dangerous Goods Shipping Regulations apply for all waters north of 60° regardless of whether they are in a Shipping Safety Control Zone or not.

The Air Pollution Regulations deal with the emission of smoke by ships while they are in Canadian waters within 1 mile of land.

The Dangerous Goods Shipping Regulations details the shipping, labeling, manifesting and packaging requirements for the transportation of dangerous goods (including wastes) by ship.

It should be noted that Kugmallit Bay (south of 69° 31') and Shallow Bay (south of 69°) are not within a shipping safety control zone and therefore the Garbage Pollution Prevention Regulations and Pollutant Substance Regulations apply in these waters.

The Garbage Pollution Prevention Regulations prohibit the discharge of garbage into the ocean. For the purposes of these Regulations "garbage " is defined as,

"solid galley wastes, food waste, paper, rages, plastic, glass, metal, bottles, crockery, junk or similar refuse."

The Pollutant Substances Regulations prohibits the discharge of pollutants into the ocean. There are over 400 chemicals classified as pollutants under these Regulations.

The Oil Pollution Prevention Regulations prohibit the discharge of an oily mixture in the ocean unless the concentration of oil is less than 100 ppm. It also requires the maintenance of an oil record book detailing all oil transfers and disposals of oil residues.

**Environmental Protection Act (NWT)**

This Territorial Government Act prohibits the discharge of contaminants to the environment. For the purpose of the Act, environment includes land, water, air and all plant and animal life of the N.W.T. It does not include the offshore. This act is superseded by all federal legislation that authorizes discharges of waste and contaminants.

The Act makes provisions for the development of any regulations necessary to carry out the purpose of the Act. At present there have been no regulations developed that might impact waste management.

Administration of the Act is handled by the Pollution Control Division of the Department of Renewable Resources, Government of N.W.T.

**Environmental Rights Act (NWT)**

This territorial legislation was implemented to provide environmental rights for the people of the Northwest Territories. It provides public access to environmental information in the possession of or under the control of the minister concerning the quantity, quality or concentration of any contaminant released or likely to be released into the environment.

The Act makes provisions for investigations by the Government at the request of the public into allegations of contaminants being released into the environment. It also provides for the prosecution of statutory offences and of any person releasing any contaminant into the environment.

**Fisheries Act**

This Federal Act deals with all aspects of fisheries, including pollution control and is aimed at the protection, conservation and preservation of fisheries in Canada. Section 36(3) prohibits the deposit of deleterious waste in water frequented by fish or in any place or under any conditions where such deleterious substance may enter such water. This section does not apply if the deposit of waste is authorized under any other act. However, if you exceed the limits authorized by the other Act you can then be held liable under the Fisheries Act, as well as the Act you were originally authorized under.

Section 36(3) of the Fisheries Act is enforced by the Environmental Protection Service (EPS) of the Federal Department of Environment.

**Government Organization Act**

The Government of Organization Act, 1970, created the Department of Environment with duties to protect and enhance quality of the natural environment, including water, air, and soil quality.

**Hazardous Materials Information Review Act**
**Hazardous Products Act**

The Hazardous Materials Information Review Act came into force October 31, 1988, amending the Hazardous products Act and providing a mandate for the implementation of the *Workplace Hazardous Materials Information System* (WHMIS). The Controlled Products Regulations require that suppliers of hazardous materials provide adequate labeling and material safety data sheets (MSDS), as a condition of import or sale. The Hazardous Materials Information Review Regulations established a commission to rule on claims and appeals

related to exemptions under the WHMIS program. The *Ingredients disclosure List* names some 1,400 chemicals which fall under the WHMIS program.

**Migratory Birds Convention Act**

Deposits of oil in or near water and on ice frequented by birds is prohibited.

**Northern Inland Waters Act**

The purpose of this Act, and its accompanying Regulations is to provide for the proper conservation, development and utilization of the water resources of the Yukon and N.W.T. The Regulations establish the procedures for licensing projects for the use of water or discharge of waste into inland waters. A water license in not required if the proposed use is for water engineering purposes, the use will continue for less than 270 days or the quantity of water used is less than 50,000 gallons per day. If a waste is to be deposited into inland waters a licenses may be required. This requirement is reviewed on an individual basis. Allowable concentrations and volumes of water to be discharged would be regulated as part of the license requirements.

This Act is administered by the Water Resources Section of the Department of Indian Affairs and Northern Developments.

**Occupational Safety and Health (Federal and Territorial)**

Standards to protect workers from exposure to hazardous materials and wastes, as well as standards reflecting general safe working conditions are administered under OSH, and OH&S.

**Oil & Gas Production & Conservation Act**

This Act provides for the control of all aspects of oil and gas exploration and development both onshore and offshore, including pollution prevention. It is the principle statue by which oil and gas related activities are regulated and makes provisions for the development of regulations to control drilling and production activities.

The Canada Oil & Gas Drilling Regulations cover disposal of all wastes generated from a drilling operation. The regulations so not specify or identify approved methods but state that the disposal must be in a manner approved by the National Energy Board.

Part 8 of the Canada Oil & Gas Production & Conservation Regulations covers disposal of all waste generated from oil and gas production operations. The regulations outline prohibitions for disposal of wastes and state that disposal must be in a manner that does not create a hazard to the natural environment.

The Oil and Gas Spills and Debris Liability Regulations limits the monetary liability for clean-up of a spill.

The National Energy Board Waste Treatment Guidelines detail how the various wastes produced from exploration activities may be disposed, sets limits for pollutants, outlines sampling schedules and reporting requirements.

**Public Health Ordinance (Yukon)**

The Yukon Public Health Ordinance regulates waste disposal locations and prohibits contamination of drinking water sources.

**Public Lands Grants Act**

This Act provides for the disposition of Federal Crown land not already under other legislative control. Leases and/or licenses are issued under the Act for disposition of lands and may contain any environmental conditions appropriate under other Federal legislation. The lease usually has conditions attached detailing how and where wastes may be disposed of.

The Act is administered by the Land Resources Section of DIAND. Land Resources depend on the Arctic Waters Advisory Committee (AWAC) to provide the environmental conditions it feels are appropriate for inclusion in the lease of license.

**Territorial Lands Act (Federal)**

The Quarrying Regulations and the Land Use Regulations set up under this act provide for the issuance of permits authorizing companies or individuals to carry out specific land use operations at specified times and locations. Conditions are appended to the permits detailing how wastes associated with the particular land use must be disposed of.

In the Beaufort Sea region, these regulations are administered by DIAND.

**Transportation of Dangerous Goods Act**

This Federal Act deals with the transportation of dangerous goods and hazardous wastes by ship, truck, rail and aircraft registered in Canada, whether in or outside of Canada. All shipments of dangerous goods must be accompanied by a manifest and be packaged and marked with all prescribed safety standards and marks. The manifest must provide information on the types and amounts of hazardous wastes or goods being shipped, and information on treatment, storage and/or disposal of the material once it reaches it's final destination. The regulations provide information on the types of material considered dangerous, definitions of hazardous waste, minimum quantities, proper shipping names, labeling instructions and product identification numbers.

The federal act provides broad coverage, but it also makes provisions for specific provincial/territorial legislation. In this way the control over the transport of dangerous material in enforced by two levels of government concurrently. The provincial/territorial authorities are responsible for the control of road transportation, while federal agencies are responsible for ensuring compliance within the air, marine and rail sectors of transport.

The government of the Northwest Territories brought the Transportation of Dangerous Goods Regulations (NWT Reg. 048-85) into force September 20, 1985. These regulations adopted federal TDG regulations, with the exceptions of: removing references to modes of transportation other than highway traffic; and, the establishment of a spill report line. In the Northwest Territories the Act as it

relates to road transport, is enforced by the Pollution Control Division, Department of Renewable Resources of the Government of the N.W.T..

The Federal Transportation of Dangerous Goods Regulations controlling air and marine transport are administered by transport Canada. Marine transport is jointly enforced by the Canadian Coast Guard and the Transportation of Dangerous Goods Directorate in Winnipeg. Air transport in the Western Arctic is controlled by Transport Canada's Western Region Headquarters in Edmonton.

**Yukon Environment Act**

The Yukon Environmental Act is a a new act which was passed by the Legislative Assembly on May 29, 1991. This act applies to land managed by the Yukon government, federal lands and First Nation settlement lands. The purpose of this Act is to protect the environment; ensure wise management of the environment; promote sustainable development; ensure complete consideration of environmental; social and economic effects in public policy making; recognize the interests of the Yukon resicdents in the regional, national and global environment; to use the knowledge and experience of Yukon residents in making public policy on the environment; and to increase involvement by Yukon residents in decisions that affect the environment.

The Ministry of Community and Transportation Services is responsible for preparing special waste management plans for the entire Yukon. These plans will describe the design, location, operation, and closure plans for disposal and storage facilities. They must be completed by 1993.

## A.2 Applicable Canadian Guidelines, Codes, or Studies

The Canadian Environmental Protection Act, authorizes the development of guidelines and codes for environmentally sound practices as well as objectives setting desirable levels of environmental quality. To date, Canada at a federal level has developed no codes of practice or guidelines on the specific issues of treatment, storage or disposal of oily waste from spills of oil and hazardous substances.

The Canadian Council of Ministers of the Environment (CCME) has however produced several documents on the related topics of: used oil management; national guidelines for the landfilling of hazardous waste; and, quality criteria for contaminated sites. These and other documents, as they relate to the treatment and disposal of oily debris, are summarized below.

**Arctic Waters Oil Transfer Guidelines**

To be reviewed.

**Interim Canadian Environmental Quality Criteria for Contaminated Sites**
Report CCME EPC-CS34, September, 1991.

The Interim Canadian Environmental Quality Criteria for Contaminated Sites were developed to promote consistency in the assessment and remediation of sites under the National Contaminated Sites Remediation Program. The report provides numerical limits for contaminants in soil and water which are "intended to maintain, improve, or protect environmental quality and human health at contaminated sites". The interim environmental quality criteria include values for the assessment and remediation of water and soil in the context of agricultural, residential/parkland, and commercial/industrial land uses. The report and criteria are intended to provide general technical and scientific guidance to provincial, federal territorial and non-governmental agencies in the assessment and remediation of contaminated sites in Canada. The Interim Canadian Environmental Quality Guidelines for Contaminated Sites includes two criteria for both soil and water quality: assessment criteria; and, remediation criteria. Assessment criteria are approximate analytical detection limits for contaminants. Remediation criteria are to be used as benchmarks to identify the need for further investigation, or remediation.

These interim assessment and remediation criteria can be used as:

- indicators of the environmental quality of a site;
- guidance for determining when further investigation of a site is required;
- guidance for determining when site remediation, risk assessment, or risk management are necessary;
- guidance for ensuring site remediation is performed to acceptable levels;

- the basis for the establishment of site specific objectives; or,
- the basis for the development of legally enforceable standards.

Although the interim Canadian environmental quality criteria for contaminated sites do not directly apply to the issue of handling, storage or disposal of oiled spill debris, much of the information contained within it could aid in monitoring a storage or disposal site, and ensuring that the wastes are not negatively impacting the environment, or the workers.

**National Guidelines for the Landfilling of Hazardous Waste**
Report CCME-WM/TRE-028, April 1991

This guideline was developed as part of the CCME Hazardous Waste Action Plan announced in March 1987. It is intended to act as a reference on the basic design, operating and performance standards to be used by federal and provincial regulatory agencies, designers, owners and operators of hazardous waste landfills in Canada. It establishes guidelines on the following areas:

- utilizing the landfill component of an integrated hazardous waste management system;
- wastes acceptable for disposal in a hazardous waste landfill;
- site selection, design and construction;
- operation and monitoring; and,
- closure and post-closure.

This is an excellent source document providing guidelines on all aspects of siting, designing and operating a hazardous waste landfill. It also contains a comprehensive bibliography.

**Used Oil Management in Canada: Existing Practices and Alternatives**
Report CCME-TS/WM-TRE007, August 1989

To facilitate the re-use and recycling, and where necessary, proper treatment and disposal of used oils, the subject of used oil management in Canada was researched and the existing practices and alternatives were documented in the report Used Oil Management in Canada: Existing Practices and Alternatives. This report is intended to serve as a background document for developing

programs and controls within various Canadian jurisdictions. Specifically, it provides an overview of the current used oil situation including quantities, legislation and present methods and practices of handling, transporting, re-using, recycling, treating and disposing of used oils in Canada; and, assesses the present and best available technologies and practices for the management of used oils in Canada with an emphasis on the economic benefits of alternative strategies leading to a recommended practice for managing used oils in Canada.

The report deals only with used oils which it defines as:

> ... an oil from industrial and non-industrial sources which has been acquired for lubricating and other purposes and has become unsuitable for its original purpose due to the presence of impurities or the loss of original properties. Used oil includes: lubricating oils (engine, turbine or gear); hydraulic fluids (including transmission fluids); metalworking fluids (including cutting, grinding, machining, rolling, stamping, quenching and coating oils); and insulating fluid or coolant (e.g., transformer fluid).
>
> Used oil does not include crude or fuel oils spilled onto land or water; wastes from petroleum refining operations; or, oils derived from animal or vegetable fats;

The report presents valuable comments on the following issues:

> current legislation; waste classification; handling and transport; used oil reprocessing and re-refining; used oil end uses; used oil disposal; and, socio-economic implications (all of which may be related to the handling of recovered oil and oily debris from spill situations).

Selective relevant conclusions from the report are reproduced below:

- Re-refining and reprocessing of used oils are the most desirable re-utilization options from an environmental and resource conservation point of view. Environmental effects are reduced by concentrating used oil contaminants in by-products which are relatively easy to control and the lubricating value of the original oil is conserved.

- Of the available re-refining technologies, distillation processes (vacuum distillation/hydrotreating and vacuum distillation/clay) are more desirable economically and environmentally than the older acid/clay treatment technologies.

- With adequate flue gas emission controls, used oils can be burned as supplementary fuel in cement kilns and boilers with acceptably low environmental risks.

- Hazardous waste incineration and treatment/authorized hazardous waste landfilling can be used to dispose of used oil in an environmentally acceptable manner.

- Common used oil utilization/disposal practices such as road oiling, landfilling of untreated used oil, sewer disposal, uncontrolled burning in small heaters and indiscriminate dumping generate environmental effects that are at best ill-defined, and at worst, a clear threat to air, soil, surface water and groundwater quality.

- Re-refining generally provides a lower economic return on investment than controlled burning. The economic viability of re-refining is further compromised when world crude oil prices are low due to strong competition from virgin lube oil refiners and a limited availability of used oil feedstocks.

- The disposal of used oil is the most costly management practice when it is done in an environmentally acceptable manner (i.e., incineration or solidification followed by disposal in an authorized hazardous waste landfill). In addition, used oil disposal is not attractive as it does not utilize the heating or lubricating resource value of used oil.

**Code of Practice for Used Oil Management in Canada**
Report CCME-TS/WM-TRE006E, August 1989

Based on Used Oil Management in Canada: Existing Practices and Alternatives, the review of existing waste oil management practices and alternatives described above, a "Code of good practice" was developed. The report Code of Practice for Used Oil Management in Canada describes environmentally sound options for the handling, storage, collection, transportation, recycling, re-use and disposal of used oils in Canada. As described above in the discussion on Used Oil Management in Canada: Existing Practices and Alternatives this report deals only with "used oils", however it does contain valuable information that could be applied to the selection and design of Beaufort Sea Oily waste Disposal and Storage Sites.

Areas of particular relevance may include the discussions on:

- Oil storage containers;
- Reprocessing and Re-refining;
- Burning
  - Boilers
  - Cement Kilns
  - Other Burners
  - Recommended Burning Practices;
- Other Re-Use Practices
  - Road Oiling
  - Asphalt Production
  - Miscellaneous end users
  - Recommended Practices for Other Re-Uses;
- Disposal
  - Incineration
  - Landfilling
  - Landfarming
  - Sewer Disposal
  - Indiscriminate Dumping
  - Recommended Disposal Practices;
- Guidelines for the Development of Used Oil Management Strategies.

**NWT Policy/Guidelines**

Pollution Control Division, Department of Renewable Resources, Government of the Northwest Territories

Land disposal of waste on NWT controlled land (i.e., lands surrounding communities) comes under the jurisdiction of the Pollution Control Division, Department of Renewable Resources, Government of the Northwest Territories. Pollution Control oversees the clean-up of spills and disposal of spill related wastes from small spills on NWT administered lands. They will review spill contingency plans, and provide support to communities responding to a spill. Pollution Control has developed no guidelines or policy on handling spill related debris. They have no publications on related topics, and look to industry to responsibly prepare for spills and develop contingency plans.

**A Community - Based Regional Land Use Plan for the Mackenzie Delta - Beaufort Sea Region**

Mackenzie Delta - Beaufort Sea Region Mackenzie Delta - Beaufort Sea Region Land Use Planning Commission, October, 1991

The Mackenzie Delta - Beaufort Sea Land Use Planning Commission, on October 18, 1991, submitted for approval the Land Use Plan for the Mackenzie Delta - Beaufort Sea Region. The plan was developed over a period of four years with support and participation by the aboriginal peoples, government planning partners, industry, public interest groups, and many government agencies. This plan and it's recommendations are consistent with and complementary to the Gwich'in and Inuvialuit land claims agreements. The planning commission's recommendations regarding waste management are reproduced below.

1. The Commission recommends that Department of Indian and Northern Affairs, the Government of the Northwest Territories, and the communities cooperate in the clean-up of waste sites that are their respective responsibilities. The parties that created waste sites should be responsible for cleaning them up. The Department of Indian and Northern Affairs should assume responsibility for all orphan sites. The Commission urges long-term Treasury Board commitments to the Arctic Environmental Strategy's waste clean-up program. Sites identified by several Community Working Groups as high priority for clean-up are: Shoran Lake, Johnson Point, Jessie Harbour, Muskox Mine and Grand Roy Mine sites, James Creek, Martin House, the "6-mile" area in the West Channel of the Mackenzie River, Richards Island, the intermediate Distant Early Warning Line Sites that were abandoned in the early 1960's, and existing sites that will be decommissioned as part of Canada's adoption of the North Warning System. The clean-up of potentially polluting wastes should be a priority throughout the region.

2. The Commission recommends that the federal and territorial waste management agencies cooperate with the Inuvialuit and Gwich'in land management authorities in the development of a comprehensive waste management strategy for the planning region. The strategy should make use of the maps of land management categories presented in Appendix E and it should address the range of wastes present in the region. It should also involve community consultations on waste facility siting.

3. The Commission recommends that marine disposal of wastes in the planning region be ultimately banned. In the interim, it recommends, following Part 3, Sec. 3(4) of the Canadian Environmental Protection Act, that land-based alternatives be preferred over ocean disposal, as a matter of federal policy. Land-based alternatives should be developed as part of the comprehensive waste management strategy recommended above.

**Handling and Disposal of Waste Drilling Fluids from On-Land Sumps in the Northwest Territories and Yukon**

Environmental Studies Research Fund Report No. 093, February 1988

This report is a consolidation of two reports on the disposal of waste drilling fluids from on-land wells in northern Canada, previously prepared by Hardy BBT Limited and Stanley Associates Engineering Ltd. The objectives of the two reports were to examine current practice, to consider future drilling needs and to recommend: (i) improvements in methods of disposing of waste fluids; (ii) the suitability of methods for different well types and locations; and (iii) the regulation of disposal.

Although oil based drill muds are one of three commonly used drilling fluid systems, deposition of oil based muds into sumps is generally prohibited, and therefore oil disposal in sumps was not considered in this report. This does not mean however that this report is not of value when examining considerations revolving around the issues of oiled debris storage and disposal. This report , in its examination of waste drilling fluid disposal, examines many areas that parallel the issue of landfilling oiled debris. The report examines issues such as: economic consideration; potential for terrain damage associated with construction and disposal; and toxicity. It examines in detail the areas of: typical operations; sump construction; sump operations; containment; and, abandonment and restoration, specifically examining such considerations as:

- physical disturbance
  - -sump location
  - - sump size
  - - terrain disturbance
  - - fluvial erosion
  - - thermal erosion

- chemical contamination
  - aquatic biota
  - vegetation and soils
  - water quality
  - fluid toxicity
  - fluid volumes
- regulatory concerns

Handling and Disposal of Waste Drilling Fluids from On-Land Sumps in the Northwest Territories and Yukon also contains a valuable listing of references in it's bibliography.

**British Columbia Marine Oil Spill Contingency Plan, Appendix 6 - Guidelines for Waste Disposal**

The guidelines for waste disposal outline the strategy, objectives, and authority for waste treatment/disposal, including sections on waste identification, categorization and treatment /disposal alternatives.
A copy of these guidelines is attached to this appendix.

**Current Studies**
**Province of British Columbia, Ministry of Environment , Lands and Parks**

Following the Nestucca oil spill (1988) the subsequent Report to the Premier on Oil Transportation and Oil Spills (1989), and the Final Report on the States/British Columbia Oil Spill Task Force (1990), determined that plans for on-shore treatment/disposal of oily wastes needed to be improved. Presently the Province is responsible for the disposal of oily wastes from marine spills. The British Columbia Ministry of Environment, Lands and Parks has identified four issues related to treatment and disposal of waste oil and oily debris. They are: (1) documentation of the regulatory approval process; (2) development of decision guidelines for determining options for sorting, storage, treatment, etc. of oil and oily debris; (3) an inventory of potential and existing treatment/disposal sites and facilities; and (4) development of a strategic plan that identifies and ranks disposal options for different regions of British Columbia. The Ministry is currently documenting the regulatory approval process through an internal

review and has circulated requests for proposals for work for the other facets of the work plan.

**Current Studies**
**Natural Resources Institute, University of Manitoba**

Eva Moche of the University on Manitoba undertook a study with the goals of identifying and assessing potential oiled debris disposal sites for the treatment /disposal of contaminated organic and inorganic materials arising from oil spill incidents along British Columbia's coast by means of the development of site specific selection criteria. The specific study area along British Columbia's coast was the southwest coast of Vancouver Island, along the Juan de Fuca Straight, between the communities of Sooke and Tofino. This area is recognized as a high risk area by the States/British Columbia Oil Spill Task Force.

Ms. Eva Moche presented a paper entitled Summary of the Identification and Assessment of Potential Oiled Debris Disposal Sites to Complement British Columbia's Emergency Clean-Up Efforts of Marine Oil Spills Along Juan de Fuca Straight, at the 1991 Arctic and Marine Oil Spill Program Technical Seminar, in Vancouver.

**Oiled Debris Disposal and Storage Sites: Beaufort Sea Coast**
Economic and Technical Review Report EPS 3-EC-79-3, November 1979.

This background study, conducted by Hardy and Associates for Environment Canada in 1979 involved establishing guidelines for site selection, design, construction and reclamation for landfill disposal sites, temporary storage sites and access roads. Limitations on construction, utilization and reclamation due to seasonal problems with terrain stability, logistics support and cost effectiveness were considered. In addition, alternative or novel landfill disposal and temporary storage techniques were reviewed.

As basic concepts as well as technology around landfilling specifically, and waste management in general have changed significantly since the report was prepared, the considerations used to rank the options for storage and disposal of

waste oil and oily debris need to be re-visited, and re-assessed using modern criteria.

This report and it's conclusions, although dated, are still relevant in terms of the specific research done on oily waste disposal and storage in coastal, periglacial environments.

**Directory of Reception Facilities for Marine Wastes in Canada**
Prepared for the Canadian Coast Guard by Acres International Limited, March 1990.

This report is a comprehensive directory of all fixed and mobile facilities in Canada equipped for the reception of garbage, sewage, oily wastes and chemical wastes from ships. Information on cargo tonnages and marine waste reception facilities was collected for more than 200 Canadian ports and terminals. Fifty-five ports reported the ability to receive oily wastes from vessel, either by fixed facilities (17 ports) or tank trucks (38 ports). Reception capability for oily wastes is considered generally adequate in Canada. Twenty-four ports reported the ability to receive chemical wastes from vessels. In 16 of these ports, the only reception method is by tank truck. The 8 ports that have fixed reception facilities for chemical wastes are those with oil refineries and petrochemical industries and the only chemical wastes that will be accepted are those that are petroleum based and are compatible with the refineries waste treatment plant. There are no large-scale facilities in Canada for the reception of marine chemical wastes.

This directory is arranged in chapters with a separate chapter for each province or region.

This report could be of value when assessing destinations for mobilizing waste from the Beaufort storage sites for ultimate disposal.

## A.3 Review of Major U.S. Legislation (examples)

Some of the major pieces of U.S. legislation and Departments or Agencies that have legislative controls over the handling, transportation , storage and disposal of oil spill debris are listed below. Some specific states' standards are also briefly discussed in this section.

**Comprehensive Environmental Response, Compensation, and Liability Act**
**Department of Transportation**
**Federal Clean Water Act**
**Occupational Safety and Health Administration**
**Oil pollution Act of 1990**
**Resource Conservation and Recovery Act (RCRA)**
**SARA Title III**

**State Standards**

Details of the above noted legislation are presented below:

**Comprehensive Environmental Response, Compensation, and Liability Act (CECLA)**

CERCLA, which may be better known as "Superfund" establishes mechanisms for immediate clean-up of hazardous substances or wastes from spills or from abandoned waste disposal sites. CERCLA also, through legislative mechanisms, ensures that parties responsible for spills or releases, pay for the clean-up.

**Transportation Legislation**

The United States Department of Transportation strictly regulates the movement of hazardous materials by road, rail, water and air transport. As in Canada, transport of hazardous material (including hazardous waste) by ship is regulated by the Coast Guard (U.S.).

**Federal Clean Water Act**

The Federal Clean Water Act prohibits any discharge that may cause an oily sheen, film, or discoloration upon the receiving waters. The consequence of this legislation is that all water collected during oil recovery skimming operations is prohibited from being discharged, and therefore must be stored and transported to storage, treatment and disposal facilities.

**Occupational Safety and Health Administration (OSHA)**

Standards to protect workers from exposure to hazardous materials and wastes, as well as standards reflecting general safe working conditions are administered by OSHA.

**Oil Pollution Act of 1990 (OPA)**

The Oil Pollution Act of 1990 establishes a system of oil spill liability, compensation and financial responsibility. The Act requires new contingency planning by both industry and government, and sets new construction, manning, and licensing requirements. It increases penalties, broadens enforcement responsibilities of the federal government, and enhances states' participation in the national response program. It also establishes a billion dollar federal trust fund to supplement the liability of responsible parties.

Three key provisions of the Act which could influence resources available for clean-up and therefore waste management, are: liability; financial responsibility; and contingency planning requirements.

Liability limits , under the OPA are significantly higher, generally $1 200 per gross ton, compared with $150 per ton under the Clean Water Act. Liability may be unlimited due to states' rights to impose additional liability, funding mechanisms, and requirements with respect to the discharge of oil or the removal of oil.

The Act requires evidence of financial responsibility (evidence of insurance, surety bond, guarantee, letter of credit, or qualification as a self insurer) sufficient to meet the maximum liability limits imposed.

The preparation of contingency plans, with the signing of OPA '90, was changed from a voluntary industry initiative to a mandatory legal requirement. The Act requires that the worst-case scenario be the criterion for planning, that those with interests in the plans have the opportunity to contribute to them, that the spiller alone be required to provide for all that is needed to clean up the worst-case spill, and that the plan be approved by the Federal government (as represented by the Coast Guard) and become a condition of the license to operate for the tank vessel or facility.

The liability for clean-up of spilled oil and the reporting of the spill, still overlap among three pieces of legislation: The Clean Water Act; The Oil Pollution Act; and, the Comprehensive Environmental Response, Compensation and Liability Act. Very generally speaking, the Clean Water Act prohibits the discharge of oil into water; the Oil Pollution Act establishes response legislation, and liabilities for spilled "oil"; while CERCLA establishes liabilities for the spillage of hazardous materials which would include "waste or contaminated oil", but generally not crude oil or refined fuels, as these fall under various exemptions contained within CERCLA.

**Resource Conservation and Recovery Act (RCRA)**

RCRA monitors and controls hazardous wastes from "cradle to grave". The United States Environmental Protection Agency (EPA) uses RCRA to regulate waste handling from the generator through treatment, management, and final disposal.

RCRA has "listed" hazardous wastes which are materials identified in listings in the legislation as hazardous wastes; as well as, wastes which are classified as hazardous, based on their characteristics as determined by test methods specified in the legislation. All waste from the clean-up of the Exxon Valdez oil spill was classified under RCRA, as non-hazardous waste at the time (and therefore exempt from the burdensome requirements of RCRA). Hazardous waste

classifications under RCRA have since changed and under the new stipulations, at least some of the waste would have been classified as hazardous.

Toxicity characteristics leaching potential (TCLP) is EPA's revised testing requirement for hazardous waste determination. Effective September 1990, 25 organic compounds were added to the list of chemicals tested and regulated under RCRA. The newly mandated TCLP replaces the Extraction Procedure (EP) leachate test. Eight metals, four pesticides and two herbicides were measured under the old EP leachate test, which ran from $250 - $400 a sample. The TCLP, a more sophisticated and absolute test can cost from $900 - $2 000 per sample.

Section 271 of CFR Title 40 (RCRA regulations) outlines emergency permits for handling and disposal of oil spill wastes.

**SARA Title III**

SARA Title III is a piece of legislation which grants the public the right to access information on the management and disposal actions of companies handling hazardous materials. It is commonly Known as "Community Right to Know" legislation.

**State Standards**

Lacking specific federal regulatory policy and guidance, states have developed inconsistent approaches to dealing with the disposal of petroleum-contaminated material from spill situations. Under RCRA, states may set up their own hazardous waste management programs with requirements more stringent than the federal standards. Consequently, some states classify all petroleum contaminated wastes as hazardous waste. The following summary of states' standards for dealing with the disposal of petroleum-contaminated material comes from the paper Fate of Oil and Debris Recovered from Spill Cleanup Operations, by Lt. Audrey A. Mckinley, U.S. Coast Guard, as published in the 1991 International Oil Spill Conference Proceedings.

> In California, a total petroleum hydrocarbon (TPH) level over 1 000 ppm renders the material hazardous for disposal purposes. In Massachusetts,

all used waste oil spills, gasoline spills with on-site contamination over 300 ppm TPH, and oil spills with over 300 ppm in the recovered debris require disposal as hazardous waste. Recovered material with total volatile hydrocarbon levels exceeding 50 ppm are considered hazardous in Connecticut. In Tennessee, debris with 100 ppm BTX (benzene, toluene, and xylene) must be handled like hazardous waste. New Jersey requires material containing over 3 % TPH to be regulated as hazardous waste. Vermont's law classifies petroleum petroleum-contaminated solids as hazardous waste; while each year the state legislature renews an exemption to handle the material as non-hazardous.

Most states treat petroleum-contaminated debris as a special non-hazardous waste for disposal purposes. Generally, the material must be sampled, tested, and certified an non-hazardous, and approved of by the state prior to disposal. In Virginia, TPH, BTEX (benzene, toluene, ethylbenzene, and xylene), TOX (total organic halogens), and TCLP (as described under RCRA above) for lead (for gasoline spills only) are the minimum analyses required prior to obtaining landfill disposal by the state. If the soil (debris) contains motor oil, it must be analyzed for TCLP (all metals and compounds) as well. Less than a dozen landfills in Virginia are permitted to receive petroleum-contaminated debris, and the waste going to those landfills must be less than 500 ppm TPH, 10 ppm BTEX, and 100 ppm TOX. In Vermont, landfilling is allowed for less than 100 ppm TPH. Kansas requires treatment prior to landfill disposal. In Massachusets, landfilling is usually not approved for quantities less than 50 cubic yards, and the amount a landfill is permitted to accept is determined by the degree of contamination in the material.

## A.4 Applicable U.S. Guidelines, Codes, or Studies

**Oiled Debris Disposal Plan**
Oregon Department of Environmental Quality, July 1991

The applicability, scope and policy statement from the Oregon Oiled Debris Disposal Plan are quoted below:

> These guidelines are applicable to any clean-up operation that is managed by a State and/or Federal On-Scene Coordinator. It is assumed for the purposes of these guidelines that oily waste is the result of a crude oil or fuel oil spill, where the characteristics of the material are known and well documented.
>
> Specifically, these guidelines cover the disposal of oily debris recovered during an oil spill clean-up operation. The oily debris generally includes, but is not limited to , sorbent pads and boom, sand, rock, gravel, logs, kelp, plastics, and animal remains.
>
> The General Policy of the Oregon Department of Environmental Quality during an oil spill clean-up operation is that, whenever possible, recovered oil and oily debris be recycled and reused, thereby reducing the amount of oily debris to be burned on-site or disposed of at a solid waste landfill.

The plan identifies responsibility for implementation, outlines a classification scheme for oiled debris, identifies regional disposal options (with a list of regional disposal contractors and facilities), discusses interim storage and briefly address transportation.

The Oregon plan (together with a companion Washington State document - see below) is one of the most complete legislative guidelines in North America which deals specifically with the problem of oily waste disposal.

**Oily Waste Treatment and Disposal Guidelines for Spills of Oil and Hazardous Substances in Washington State Waters**
Washington State, Department of Ecology, Spill Management Section, Contingency Planning Unit, July 1991.

These guidelines form part of the Statewide Master Oil and Hazardous Substance Spill Contingency Plan. It is a very detailed and comprehensive guideline which outlines the applicability and scope, and presents the Department of Ecology's Policy Statement.

The Policy Statement covers recovered oil, oily debris, segregation, interim storage, and final disposal. Washington State legislation (RCW 70.105 and 70.95) mandates the priorization of disposal methods, and as such, this guideline discusses the priorization of waste management methods, in the context of response to an emergency situation.

Washington has it's own legislation (Hazardous Waste Management Act, and, The Oil and Hazardous Substances Spills Act of 1990, as amended by The Spill Prevention Act of 1991) which assigns responsibility for response, and defines classification methods for classifying oily waste as dangerous waste, extremely hazardous waste, or, solid waste.

The general policy of the Department of Ecology is to, whenever possible, and to the maximum extent feasible, recycle and re-use, recovered oil and oily debris, and thus reduce the amount of oily debris incinerated or disposed of at a solid or hazardous waste landfill.

The guidelines on Interim Storage are reproduced below:

> Interim Storage can be a major impasse in the progress of the cleanup operation. With some preplanning, the matter of timely approval for a site should not be a difficult problem. Interim storage sites should be predesignated for possible use during a spill event. Use of any site is dependant on the approval of the local Health authority and (the Department of) Ecology at the time of the incident.

When considering a potential interim storage site, the following points should be reviewed:

(a) Geology
(b) Ground water
(c) Soil
(d) Flooding
(e) Surface water
(f) Slope
(g) Cover material
(h) Capacity
(i) Climatic factors
(j) Land use
(k) Toxic air emissions
(l) Security
(m) Access
(n) Public contact

Interim Storage sites should be designed to use the best achievable Technology (as defined in ESHB 1027: "Best achievable technology" means the technology that provides the greatest degree of protection taking into consideration (a) processes that are being developed, or could feasibly be developed, given overall reasonable expenditures on research and development, and (b) processes that are currently in use. In determining what is best achievable technology, the director (of the Department of Ecology) shall consider the effectiveness, engineering feasibility, and commercial availability of the technology.) to protect the environment and human health. These sites should be set up in such a manner as to prevent leakage, contact, and subsequent absorption of oil by the soil. This includes having the sites bermed and double lined with plastic or visqueen sheets 6 - 10 millimeters of greater in thickness, without joints, prior to receiving loose bagged debris. The edges of the sheet must be weighted with stones of earth to prevent damage by wind, and it should be placed on a sand layer or an underfelt thick enough to prevent piercing. A reinforced access area for vehicles at the edge of the site should be provided. In addition to, the oily debris should be covered by secured visqueen or tarps and an adequate storm water runoff collection system for the size and location of the site must be utilized.

Oily debris should be hauled to approved interim storage site in visqueen lined trucks or other vehicles. Burnable, non-burnable, treatable and re-usable materials should be placed in well defined separate areas at interim storage sites. Dangerous waste shall be stored at the interim storage sites for no more than 90 days pursuant to WAC 173-303-200. "The department may on a case-by-case basis, grant a maximum thirty day extension to this ninety day period if dangerous wastes must remain on-site due to unforeseen, temporary and uncontrollable circumstances." The contaminated materials should then be transported by registered or exempt visqueen lined trucks and/or barges to their respective final disposal sites.

When the last of the oily debris leaves an interim storage site, the ground protection should be removed and disposed of with the rest of the oily debris. Any surrounding soil which has become contaminated with oil, must also be removed for disposal or treatment. If the soils were removed for treatment they may be replaced if testing proves acceptable levels have been achieved. Treatment and remediation is encouraged in cases where it is feasible. The interim storage site must, to the maximum extent feasible, be returned to its original condition.

Priorization of disposal methods are mandated in Washington state legislation. Waste management policy in Washington state considers prevention and waste elimination or minimization to be the best choice in dealing with oil spills and disposal. As prevention may not be 100% effective, this is of limited feasibility. Once a spill has occurred, recovery, reuse and recycling are the preferred choices for remediation. Treatment is the next best alternative, but incineration and burning for energy recovery have more options within the state. There are some limitations and considerations in incinerating for disposal. Environmental quality of incineration varies with the type and age of the facility. Therefore, when incineration becomes an option during an event, local air quality authorities should be contacted for advice about efficiency and emissions of facilities within their authority. Approval of the local air authorities is a requirement for any incineration option. Landfilling is the last option. Final disposal at a solid or dangerous waste landfill is the least environmentally sound method of dealing with a waste problem such as oily debris.

The guidelines state that the identification of suitable waste treatment and disposal sites should be written in the form of an "incident disposal plan" and have the written authorization of the Washington State Department of Ecology, the U.S. Coast Guard and/or the Environmental Protection Agency. An incident disposal plan should include predesignated interim storage sites, segregation strategies, methods of treatment and disposal to be employed for various types of debris collected, and the locations/contacts of all treatment and disposal site locations. The guidelines contain several lists of different types of facilities available for treatment and disposal of oily, debris, as well as a priorization schedule for selecting appropriate methods of treating the oiled debris.

Together with the Oregon material reviewed above, the Washington document is one of the most relevant set of guidelines uncovered in this study. These two Pacific Northwest states are far ahead on the rest of North America in developing guidelines specific to the oil spill emergency problem of waste disposal.

## A.5 Case Study - The Exxon Valdez Spill, March 24, 1989

On May 1, 1989, following waste management discussions with all interested parties since the early days of the spill response effort, a waste management plan, categorized as a scoping plan" was formally released by Exxon. The overall goal of the plan was to "establish a sound operational program to handle and dispose of all spill related wastes in a safe, environmentally sound manner and in accordance with all applicable laws and regulations." The Waste Management Plan was the last of the major plans to be developed by Exxon. This is because waste management was not considered a critical path item, and waste management activities must of necessity follow the clean-up actions.

The following principles were included in developing the plan:

- Provide safe working conditions
- Minimize risk of pollution incidents in all operations
- Treat/reclaim liquid wastes to remove:
  - Oil from water
  - Trash/kelp from oils
- Segregate oily wastes, trash and expired animals

- Store oily solid wastes in bags, controlled areas, and containers
- Handle and transport oily wastes in appropriate containers/tanks
- Transport solids/semi-solids from remote areas to central areas for incineration or landfilling
- Landfill non-oily trash and ash from incinerators.

A review of all applicable regulations and standards was conducted by Exxon, forming the basis of rational for selecting the waste management strategies. This rational is detailed in section III of the plan.

Section IV of the plan identifies management strategies for liquid wastes. Liquid wastes include:

- Wastewaters from washing and cleaning operations and storage impoundments;
- Oily wastewaters from all oil skimming and collection operations;
- Heavily oiled kelp and trash contaminated oils; and,
- "Fishing boat collected" oil from the container dock area.

The basic liquid waste management objectives were to:

- Collect oil and water mixtures in a controlled, efficient way;
- Store oil and wastewaters in secure areas, onshore and offshore;
- Transport liquid wastes in a controlled manner to prevent pollution risks or recontamination of cleaned areas;
- Separate and reclaim as much usable oil for refinery processing; and,
- Dispose of treated oily waters in an environmentally sound manner.

The plan stated that:

> The liquid wastes generated from the overall spill response are very similar to those generated in production, refining and petroleum terminal operations: oily water mixtures and emulsions. The technology for handling these liquids is well known. The basic approach is to separate the oil from the water, break the emulsions with heat and/or demulsifiers, and then reclaim the usable oil and treat the waste waters prior to disposal.

The plan identified the Alyeska Ballast Water Treatment System, Barges for Storage, the oil-water separator at the Alyeska Terminal, the Alyeska Terminal sludge pit/drying bed, vacuum trucks, and the Alyeska advanced wastewater

treatment facility as equipment/facilities that would be used to accomplish the liquid waste disposal.

Section V of the plan identifies management strategies for solid wastes. Solid wastes addressed by the plan were characterized as follows:

- Non-oily wastes
  -Household type wastes from camp operations
  - Scrap wood and other materials from construction activities
  - Scrap equipment from response activities such as worn out pumps, hoses, boom ,etc.;
- Oily wastes;
- Animal carcasses;
- Incinerator ash;
- Oily booms/oil spill response equipment.

The basic solid waste management objectives were to:

- Dispose of solid wastes in an environmentally sound and operationally efficient manner
- Provide environmentally sound short term storage sites
- Minimize overall pollution potential associated with transportation, storing, and disposing of solid wastes while ensuring the disposal of solid wastes does not limit or restrict cleanup operations
- Describe Exxon's plan to regulatory agencies to facilitate identifying and obtaining all necessary permits or approvals to carry out the storage and disposal activities.

The plan stated that:

> The basic strategy is to implement small scale incineration, large scale incineration, and landfilling as rapidly as possible. This provides flexibility to accommodate permitting delays or equipment problems and ensures that waste disposal can occur at a rate that will not limit shoreline restoration activities. As operational experience is gained, one or more of the methods may be suspended in favor of the others.
>
> The non-oily wastes will be transported to Valdez for disposal at the City landfill or other suitable landfills.
>
> Oily materials will generally be placed in plastic bags to prevent pollution and facilitate the handling of recovered materials. Larger items such as oiled driftwood may be directly transferred to the burner barge or storage

barge. Oiled driftwood may also be treated by washing or by burning the oil off with weed burners, as is currently practiced by the U.S. Coast Guard.

Animal carcasses will be handled and stored separately from other solid wastes. There are existing procedures that specify all carcasses are to be delivered to the U.S. Fish & Wildlife Service (USFWS). When the USFWS wishes to dispose of the carcasses, they will be incinerated in the hospital type incinerators at the Valdez area incinerator site or in Alyeska's incinerator. The carcasses will be kept separate from other wastes to be incinerated and handled on a priority basis to ensure they are not improperly stored and allowed to decompose.

Incinerator ash from each incinerator will be tested to determine if it is hazardous or not.

Before incinerating any items constructed of plastics, they will be checked to insure they do not contain significant amounts of polychlorinated materials. Pieces of equipment that are not burnable will be cleaned and disposed of at the Valdez landfill. Consistent with Exxons's Shoreline Restoration Plan (4/15/89), we do not anticipate removal or disposal of significant quantities of oiled rocks or sand.

The plan identified two deck barges of approximately 70 - 75 feet by 250 feet, landing craft vessels, dump trucks, and conventional offshore waste containers, as equipment that would be used to transport the waste.

Temporary oily solid waste storage sites (onshore and offshore) were identified for: the Valdez area; Prince William Sound; and, areas outside of Prince William Sound.

Disposal sites and facilities were also identified in the plan. The sites sites identified in the plan, however, were often not the sites that were actually used during the clean operations, so this section of Exxon's Waste Management Plan will not be reviewed.

Actual waste management operations when compared to the original "scoping plan" differ quite substantially in terms of operational logistics, however they deviate very little from the goals or principles of the original plan. Through conversations with Mr. Rob Dragnich of the Waste Management Section of

Exxon, and a review of Exxon's report Valdez Oil Spill Technology 1989 Operations and the paper Marine Operations and Logistics During the Exxon Valdez Spill Cleanup , as presented in the 1991 International Oil Spill Conference Proceedings, the following summary of the actual waste management operations has been compiled.

**Solid Waste Handling and Disposal in the *Valdez* Cleanup**

Oily solid waste from Prince William Sound, where shoreline cleanup techniques focused on water washing, consisted mainly of oiled sorbent materials and shoreline debris. In the Gulf of Alaska, the wastes were primarily oily sands and gravel collected as a result of removing mousse patties and tarballs from the shoreline. Exxon's initial plan was to incinerate most oily solid wastes offshore on two specially developed barges. Due to concerns raised around the emissions from the proposed incinerators, and delays in the permitting process, the issuance of operating permits was delayed until just prior to the end of the cleanup operation. Due to the delays in permitting, the alternative plan of landfill disposal had to be implemented to provide for appropriate disposal and to prevent waste storage limitations from impeding the shoreline cleanup. About 90 percent of the solid waste was disposed of by landfill. Table A-1 illustrates the quantities of oily solids that were processed at the waste handling facilities.

In addition, there was a considerable amount of non-oily solid waste, which included household refuse as well as wood and metal waste generated through out the operation. The non-oily waste was sent to municipal landfills in Alaska.

Oily materials from shoreline cleanup were placed into 8 mil polypropylene bags about 5 feet by 3 feet in size. The bags were transported to a shuttle vessel or one of several central staging barges by skiffs or landing craft. The central staging barges were equipped with a crane and had ore bins (strong, watertight, steel containers) for use as waste receptacles.

Household/domestic type garbage was collect from the berthing vessels and taken to a barge equipped with a trash compactor and ore bins for storage.

Table A-1
Summary of Oily Solid Waste Disposal - *Exxon Valdez* Spill

| Processing Facility | Tons Processed |
|---|---|
| Incineration | |
| Onshore incinerators | 2 100 |
| Silo incinerator barge | 500 |
| **Total incineration** | **2 600** |
| Lower 48 landfill | |
| Anchorage repackaging facility | 15 900 |
| Seward repackaging facility | 6 500 |
| Subtotal | 22 400 |
| Absorbent added in processing | 8 000 |
| **Total landfill** | **30 400** |
| **Total oily solid waste disposal** | **33 000** |

"Circuit" barges and vessels shuttled between Valdez or Homer/Steward and the offshore central staging barges to exchange empty ore bins for full ones. In Valdez ore bins were weighed and trucked to a processing site at Dayville Road. The Dayville Road site was constructed to receive, separate/sort, store, transship and/or incinerate oily solid waste. The site had two lined concrete pads for waste sorting and two lined pits for the storage of the oily solid waste. The oily water from the concrete pads and pits was pumped into tanks and hauled to the Alyeska ballast water treatment facility by vacuum truck. The site also had areas for storing liquid waste in drums or tanks. Waste bins were emptied on the concrete pads and inspected to insure that the waste had been properly segregated. Non-oily waste, such as kitchen refuse and construction waste was sent to the Valdez municipal landfill. Oily waste was held in pits at the Dayville site. Oily PVC material was bagged and sent to a landfill in Oregon. As the cleanup operation extended into the Gulf of Alaska, a second waste processing site similar to the Dayville Road site was established at Seward. Facilities were also provided at this site, for handling recovered oil and water. Emulsions were

heated to separate the oil and water and debris was filtered out with a screen. Steam coils heated the oil for loading into a tank barge for shipment to Valdez and later to Seattle.

Oily solid waste was transported to repackaging sites in Anchorage and Seward. These facilities reduced the waste volume by shredding, and then added absorbent material to stabilize free liquids, and packaged it in special, reinforced plastic bags called "supersacks", loaded the sacks into trailers and shipped these to a secure hazardous waste landfill in Oregon operated by Chem-Security Systems in Arlington.

Non-oily wastes were sent to municipal landfills in Alaska.

Repackaging and shipment for landfill were important because they prevented the solid waste accumulation from exceeding the storage capacities at the processing facilities. About 90 percent of the solid waste was disposed of by landfill.

The incineration of waste was implemented by Exxon's utilization of five small onshore incinerators which were used until higher capacity waste handling facilities were available. Incinerators on the North Slope of Alaska and at the Alyeska Terminal in Valdez had existing permits to burn oily wastes. The North Slope incinerator was used to burn 10 - 20 tons per day. The Alyeska incinerator was rated at 300 pounds per hour and saw only limited use. Three small incinerators were installed at the Dayville Road waste site and were used to dispose of about 5 tons of waste per day. Two air curtain incinerators (one from the Beaufort Sea Oil Spill Cooperative) were tested, but the Alaska Department of Environmental Conservation did not grant permits because standard air emission limits on particulates could not be applied to an incinerator without an exhaust stack.

Exxon's original plans included plans to use a barge mounted silo incinerator, and rotary kilns as required. This would involve the use of two offshore incinerator barges. The silo hearth incinerator barge had an operating capacity of about 40 -70 tons per day. It was chosen for its early availability, positive emissions control system, simple and reliable operation, ability to directly feed

large waste materials, and ability to burn high-BTU waste. Although startup was delayed by permitting until nearly the end of the operating season, the unit did operate long enough to conduct air emissions tests. It burned about 500 tons of waste, which was a fraction of its intended use. The other incinerator barge had a rotary kiln incinerator with a projected disposal capacity of 120 tons per day of oil sand and gravel. Permitting also delayed startup of this barge, and further permitting and mechanical problems prevented its use.

Recyclable materials such as batteries and metals were shipped to appropriate recycling firms.

**Liquid Waste Handling and Disposal**

Several hundred thousand barrels of liquid wastes were generated and disposed of. Skimmed oil and water accounted for most of the liquid waste.

Free water from skimming activities and other oily waters were transported to Alyeska Pipeline Service Company's Valdez Terminal for processing through its ballast waster treating system. Other sources of oily water including water from oily solid waste storage pits and water from kelp cleaning operations were also sent to Alyeska for processing. Skimmed oil was consolidated and stored in large barges and transported to Northwest EnviroServices in Seattle or to Exxon's Baytown refinery for processing. Emulsified oil and water from skimming operations were transported to Seattle or to Exxon's Baytown refinery for processing, oil recovery, and waste water treating.

Offshore discharge of untreated black and grey waters from berthing vessels was prohibited, and initially this waste was transported by barge to the Valdez dock where it was discharged into the city of Valdez sewage treatment system. This system was upgraded at the dock to increase off-loading capacity. Due to capacity constraints in the Valdez system, a barge was modified to serve as an Aerated Treatment Lagoon (ATL) system. It was in place by June, and permitted to process 160 000 gal/day. Use of this barge simplified collection of sewage from vessels in Prince William sound. The barge did not have a sludge digester, so sludge was accumulated during treatment operations.

Waters from cleaning protective gear, boom, boats, etc., was collected and pretreated with chemical flocculation/demulsification, settling, and separation, to remove excess oil and grease to allow for treatment in the Valdez municipal sewage treatment facility. More than 70 000 barrels of such liquid waste was discharged to the city of Valdez system.

Used lube oil, waste fuel, cleaning solvents and other wastes were collected and stored in drums, transported to central staging areas, and then moved by the circuit barges and truck to the Dayville Road site where proper disposal or recycling was arranged.

## Terminology and Abbreviations for the Sensitivity Evaluation Table

*Site Code:* as per Hardy (1979) except;

(1) place names only (new candidate sites identified in Phase I of this study but not visited during Phase II);

(2) DR-1, DR-2, etc., refer to new sites not identified in the Hardy report but evaluated during the Phase II field work in this study.

*Beaufort Atlas:* shading in this column indicates that sites fall along a section of the coastline ranked in the Beaufort Sea Atlas as having a high sensitivity (Dickins, et al., 1987).

*Beaufort RLUPC:* shading in this column indicates that sites fall within areas mapped as Category E or Legally Designated (existing or proposed) by the Mackenzie Delta Beaufort Sea Regional Land Use Planning Commission in 1991.

*CWS:* shading in this column refers to the level of sensitivity to birds, as mapped by the Canadian Wildlife Service (Alexander et al., 1988). Solidly-shaded boxes indicate high sensitivity areas and striped boxes reflect variable sensitivity regions (high sensitivity in some years).

## Beaufort Sea Disposal Sites: Sensitivity Evaluation

Criteria: Accept Reject Possible Reject (Variable Use)

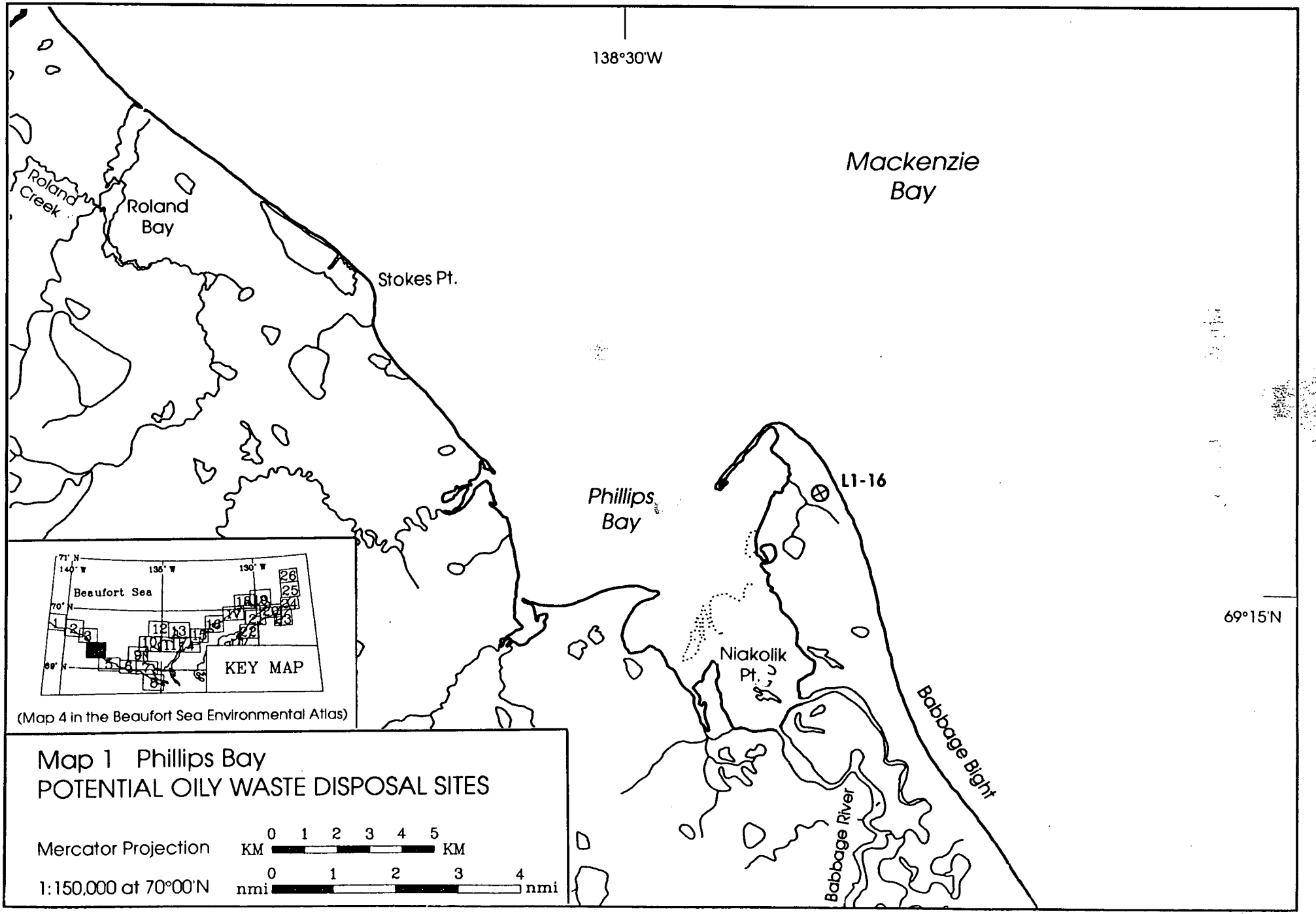
| SITE CODE | STORAGE DURATION | B.S. ATLAS | BEAUFORT RLUPC | CWS RANKING |
|---|---|---|---|---|
| L1-A-C | L/M | | | |
| T1-1 | S/M | | | |
| L1-2 | L/M | | | |
| T1-2 | S/M | | | |
| T1-3 | S/M | | | |
| L1-4 | M/L | | | |
| T1-4 | S/M | | | |
| T1-18 | S/M | | | |
| L1-5 | M/L | | | |
| T1-5 | S | | | |
| T1-6 | L | | | |
| T1-6 | S/M | | | |
| L1-7 | M | | | |
| T1-7 | S | | | |
| L1-8 | S | | | |
| S. OF WORKBOAT | S | | | |
| T1-19 | S/M | | | |
| T1-9 | S/M | | | |
| L1-9A-C | M/L | | | |
| T1-10 | S/M | | | |
| T1-11 | S | | | |
| T1-12 | S | | | |
| L1-12A,B | M/L | | | |
| T1-13 | S | | | |
| STOKES PT. DLS | S/M/L | | | |
| T1-14 | S/M | | | |
| L1-14 | M/L | | | |
| T1-15,20 | S/M | | | |
| L1-15 | M | | | |
| T1-16 | S/M | | | |
| L1-16 A,B | M/L | | | |
| L2-1 | L | | | |
| KING POINT | S | | | |
| T2-6 | S | | | |
| T2-2 | S | | | |
| T2-3 | S | | | |
| L2-2 | M/L | | | |
| L2-3 | M/L | | | |
| T2-4 | S/M | | | |
| T2-5 | M/S | | | |
| L2-5 | M/L | | | |
| T3-5 | S | | | |
| T3-4 | S | | | |
| T3-6 | S | | | |
| L3-4 | M | | | |

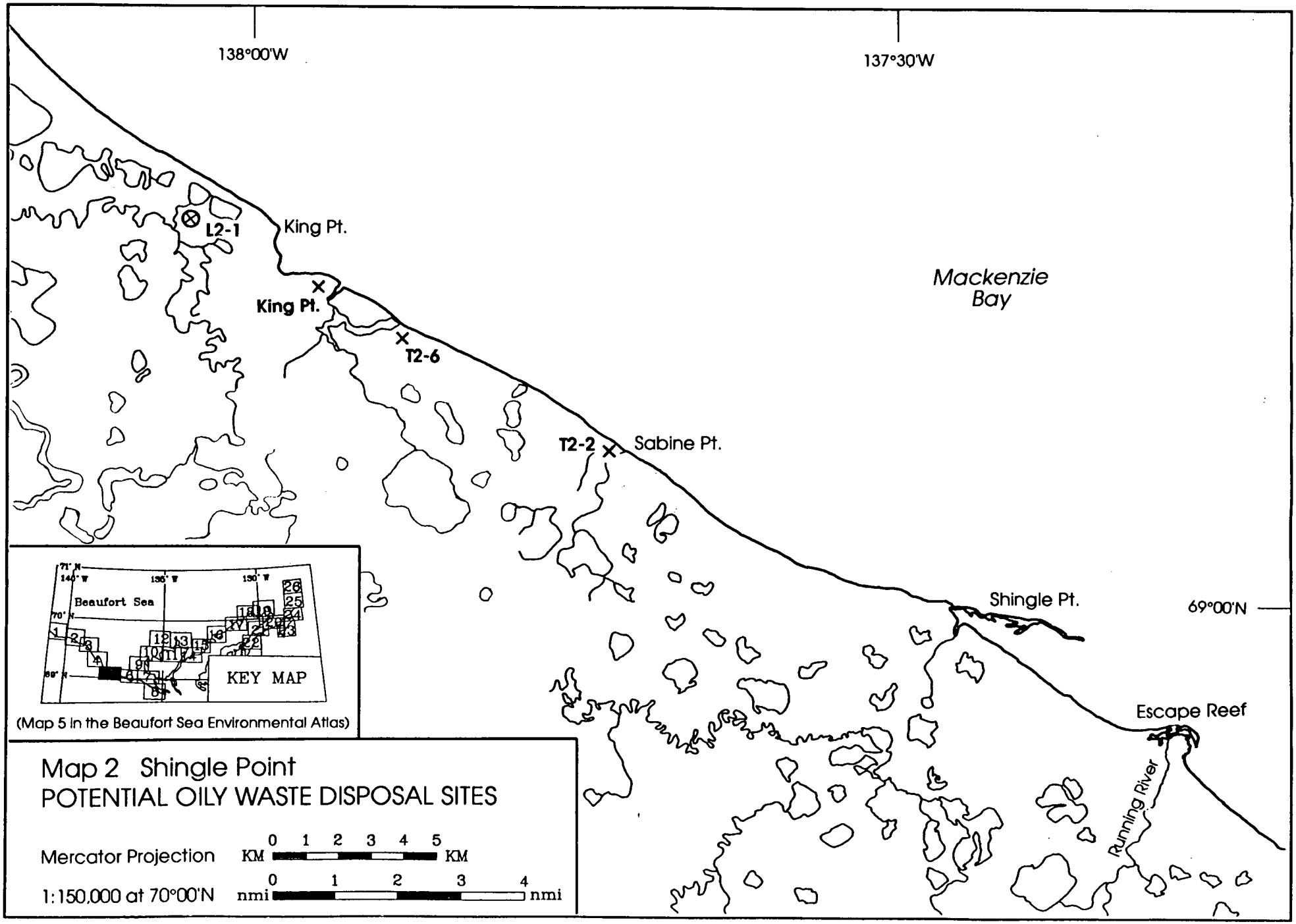
| SITE CODE | STORAGE DURATION | B.S. ATLAS | BEAUFORT RLUPC | CWS RANKING |
|---|---|---|---|---|
| T6-15 | S | | | |
| L6-15A | M/L | | | |
| CAMPBELL ISLAND | S | | | |
| W OF NICHOLSON | S/M | | | |
| L7-46 | L | | | |
| T7-46 | S | | | |
| T7-47 | S | | | |
| T7-40 | S | | | |
| T7-41 | S | | | |
| L7-40 | M | | | |
| T7-43 | S | | | |
| T7-44 | S | | | |
| T7-45 | S | | | |
| L7-42 | L/M | | | |
| L7-43 | L/M | | | |
| T7-42 | S | | | |
| T7-39 | S/M | | | |
| L7-39 | L | | | |
| T7-38 | S | | | |
| T7-36 | S | | | |
| L7-36 | M/L | | | |
| L7-38 | M/L | | | |
| T7-35 | S | | | |
| T7-37 | S | | | |
| L7-35 | M/L | | | |
| T7-33 | S | | | |
| T7-34 | S | | | |
| T7-32 | S | | | |
| L7-34 | M | | | |
| L7-32 | M/L | | | |
| T7-30 | S | | | |
| T7-31 | S | | | |
| L7-31 | M | | | |
| L7-28 | M | | | |
| T7-28 | | | | |
| T7-29 | S | | | |
| L7-25 | M/L | | | |
| L7-26 | M/L | | | |
| T7-26 | S | | | |
| T7-24 | S | | | |
| L7-24 | M/L | | | |
| L7-27 | M/L | | | |
| L7-22 | M/L | | | |
| L7-21 | M/L | | | |
| L7-20 | M/L | | | |
| L7-19 | M/L | | | |
| L7-17 | M/L | | | |
| L7-16 | M/L | | | |
| L7-15 | M/L | | | |

| SITE CODE | STORAGE DURATION | B.S. ATLAS | BEAUFORT RLUPC | CWS RANKING |
|---|---|---|---|---|
| T4-49 | S | | | |
| L4-47 | M/L | | | |
| L4-49 | M/L | | | |
| L4-50 | M/L | | | |
| T4-50 | S | | | |
| DRIFT POINT | S | | | |
| DRIFT POINT | M/L | | | |
| T4-51 | S | | | |
| L4-51 | M/L | | | |
| L4-52 | M/L | | | |
| T4-52 | S | | | |
| T4-53 | S | | | |
| MCKINLEY BAY W. | S | | | |
| MCKINLEY BAY E. | S | | | |
| L4-54 | M | | | |
| T4-54 | S | | | |
| T4-55 | S | | | |
| T4-56 | S | | | |
| L4-55 | M/L | | | |
| L4-56 | M/L | | | |
| SEAL BAY | S/M | | | |
| NUVORAK POINT | S/M | | | |
| RUSSELL INLET #1 | S/M | | | |
| RUSSELL INLET #2 | S/M | | | |
| RUSSELL INLET #3 | S/M | | | |
| T4-57 | S | | | |
| T4-58 | S | | | |
| T4-59 | S | | | |
| L4-60 | M/L | | | |
| DR-1 (CAPE DALHOUSIE) | S/M | | | |
| CAPE DALHOUSIE EAST | S/M | | | |
| DR-2 (JOHNSON BAY) | S/M | | | |
| DR-3 (PULSATING PINGO) | S/M | | | |
| L6-1 | M/L | | | |
| T6-1 | S | | | |
| T6-2 | S | | | |
| L6-2 | M/L | | | |
| T6-3 | S | | | |
| T6-4 | S | | | |
| L6-4 | M | | | |
| L6-5 | M | | | |
| T6-5 | S | | | |
| T6-6 | S | | | |
| T6-7 | S | | | |
| L6-8 | M/L | | | |
| L6-10 | M/L | | | |
| L6-9 | M/L | | | |
| L6-11 | M/L | | | |
| T6-11 | S | | | |

| SITE CODE | STORAGE DURATION | B.S. ATLAS | BEAUFORT RLUPC | CWS RANKING |
|---|---|---|---|---|
| L3-6 | M | | | |
| T3-7 | S | | | |
| T3-9 | S/M | | | |
| T3-10 | S/M | | | |
| L3-9 | M | | | |
| L3-10 | M | | | |
| T3-8 | S | | | |
| L3-8 | L | | | |
| T3-3 | S | | | |
| T3-2 | M | | | |
| T3-1 | M/S | | | |
| T3-11 | S | | | |
| T3-17 | S | | | |
| L3-11 | M/L | | | |
| RICHARDS ISLAND NORTH | S/M | | | |
| RICHARDS ISLAND SOUTH | S/M | | | |
| T3-12 | S | | | |
| T3-16 | S | | | |
| L3-12 | M/L | | | |
| T3-13 | S | | | |
| T3-14 | S | | | |
| L3-14 | M/L | | | |
| L3-15 | M/L | | | |
| T3-15 | S | | | |
| L3-13 | M/L | | | |
| HANSON HARBOUR | S/M | | | |
| DR-4 (HADWEN IS.) | S/M | | | |
| SUMMER ISLAND | S/M | | | |
| N. OF KIDLUT BAY | S/M | | | |
| S. OF KIDLUT BAY | S/M | | | |
| HENDRIKSON ISL. | S/M | | | |
| T4-2 | S | | | |
| T4-3 | S | | | |
| L4-2 | M | | | |
| T4-4 | S | | | |
| T4-5 | S | | | |
| L4-4 | M/L | | | |
| T4-7 | S | | | |
| T4-8 | S | | | |
| T4-6 | S | | | |
| L4-6 | M/L | | | |
| 'TUK WEST' | S | | | |
| L4-9 | M/L | | | |
| (L4-11) | S/L | | | |
| L4-13 | M | | | |
| T4-13 | S | | | |
| T4-14 | S | | | |
| T4-15 | S | | | |
| L4-15 | L | | | |

| SITE CODE | STORAGE DURATION | B.S. ATLAS | BEAUFORT RLUPC | CWS RANKING |
|---|---|---|---|---|
| T4-16 | S | | | |
| T4-17 | S/M | | | |
| L4-17 | M/L | | | |
| T4-19 | S | | | |
| L4-18 | M/L | | | |
| T4-20 | S | | | |
| L4-20 | M/L | | | |
| L4-21 | M/L | | | |
| T4-21 | S | | | |
| T4-22 | S | | | |
| T4-23 | S | | | |
| T4-24 | S | | | |
| T4-25 | S | | | |
| L4-24 | M/L | | | |
| T4-26 | S | | | |
| T4-27 | S | | | |
| L4-26 | M/L | | | |
| L4-28 | L | | | |
| L4-29 | M/L | | | |
| T4-28 | S | | | |
| T4-29 | S | | | |
| T4-46 | S | | | |
| L4-46 | L | | | |
| L4-40 | M | | | |
| T4-41 | S | | | |
| T4-40 | S | | | |
| T4-43 | S | | | |
| T4-44 | S | | | |
| T4-45 | S | | | |
| L4-43 | M/L | | | |
| L4-38 | M/L | | | |
| L4-37 | M/L | | | |
| T4-39 | S | | | |
| T4-38 | S | | | |
| T4-37 | S | | | |
| L4-30 | M/L | | | |
| L4-32 | M/L | | | |
| T4-30 | S | | | |
| T4-31 | S | | | |
| T4-32 | S | | | |
| T4-33 | S | | | |
| L4-33 | M/L | | | |
| L4-34 | M/L | | | |
| L4-36 | M/L | | | |
| T4-36 | S | | | |
| T4-42 | S | | | |
| L4-42 | M | | | |
| T4-48 | S | | | |
| T4-47 | S | | | |

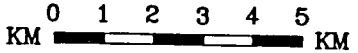

138°30'W
Mackenzie Bay
Roland Creek
Roland Bay
Stokes Pt.
Phillips Bay
L1-16
Niakolik Pt.
Babbage Bight
Babbage River
69°15'N
Beaufort Sea
KEY MAP
(Map 4 in the Beaufort Sea Environmental Atlas)
Map 1 Phillips Bay
POTENTIAL OILY WASTE DISPOSAL SITES
Mercator Projection
1:150,000 at 70°00'N
0 1 2 3 4 5 KM
0 1 2 3 4 nmi

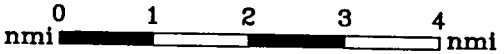

138°00'W
137°30'W
L2-1
King Pt.
King Pt.
T2-6
T2-2
Sabine Pt.
Mackenzie Bay
Shingle Pt.
69°00'N
Escape Reef
Running River
Beaufort Sea
KEY MAP
(Map 5 in the Beaufort Sea Environmental Atlas)
Map 2 Shingle Point
POTENTIAL OILY WASTE DISPOSAL SITES
Mercator Projection
1:150,000 at 70°00'N
0 1 2 3 4 5
KM
KM
0 1 2 3 4
nmi
nmi

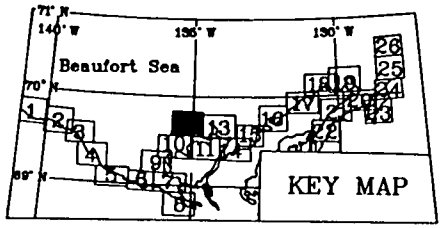
# Map 3 Pelly Island
# POTENTIAL OILY WASTE DISPOSAL SITES

Mercator Projection

1:150,000 at 70°00'N




(Map 12 In the Beaufort Sea Environmental Atlas)

135°00'W

69°45'N

135°30'W

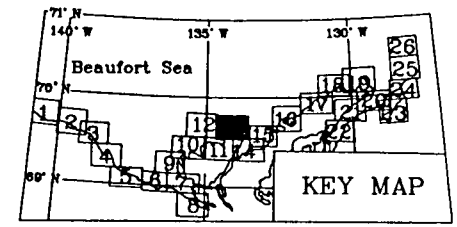
T3-1

HOOPER ISLAND

PELLY ISLAND

# Map 4 North Point
## POTENTIAL OILY WASTE DISPOSAL SITES

Mercator Projection
0 1 2 3 4 5 KM
1:150,000 at 70°00'N
0 1 2 3 4 nmi




(Map 13 in the Beaufort Sea Environmental Atlas)

134°30'W

69°45'N

134°00'W

PULLEN ISLAND

T3-15
T3-14
L3-15
L3-14
T3-13
North Head
L3-13
L3-12
T3-16
T3-12

REINDEER ISLANDS

Hanson Harbour

Kugmallit Bay

Richard's Island North

Richard's Island South

NORTH POINT

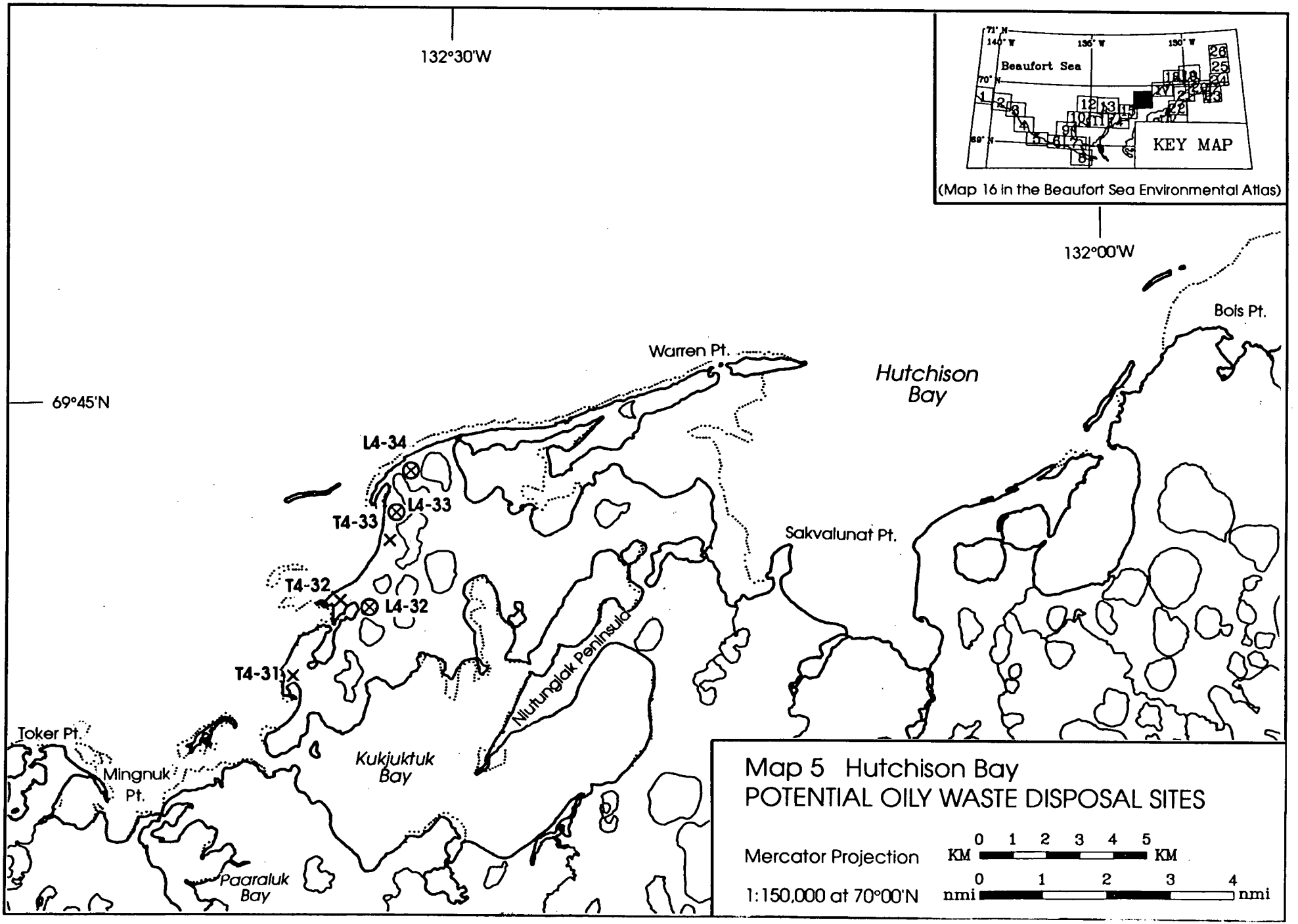
Wallace Bay

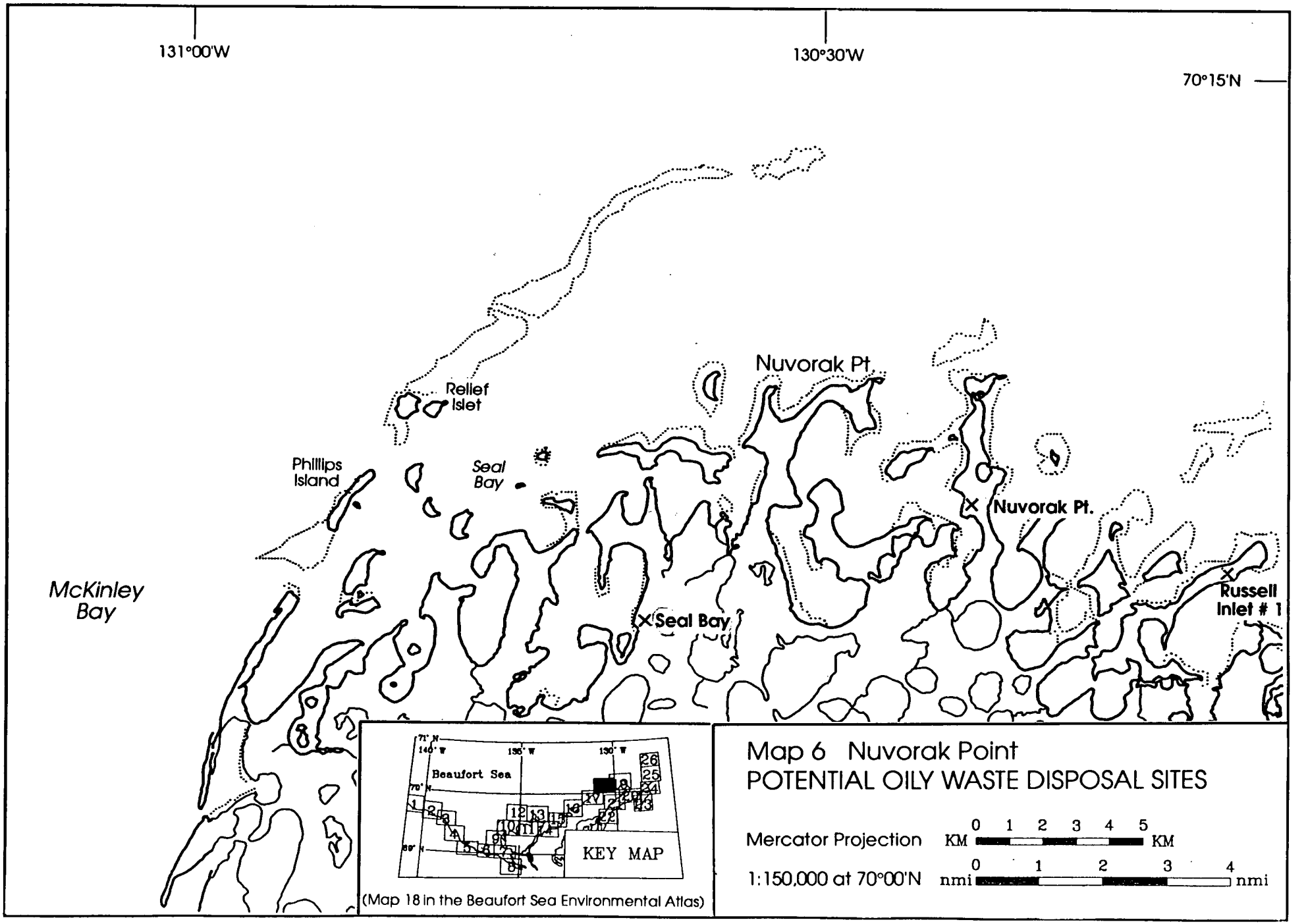
DR-4

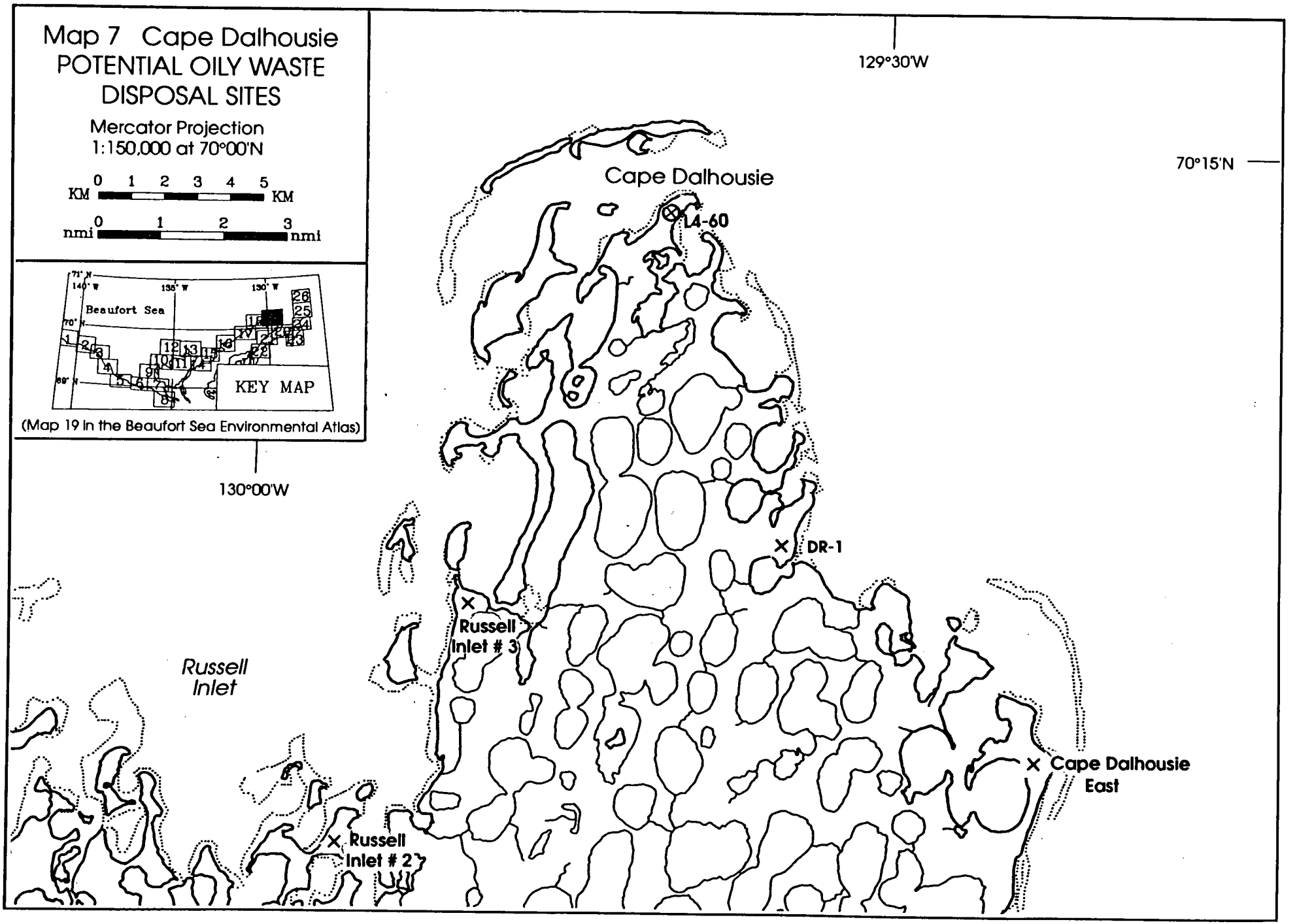
HADWEN ISLAND

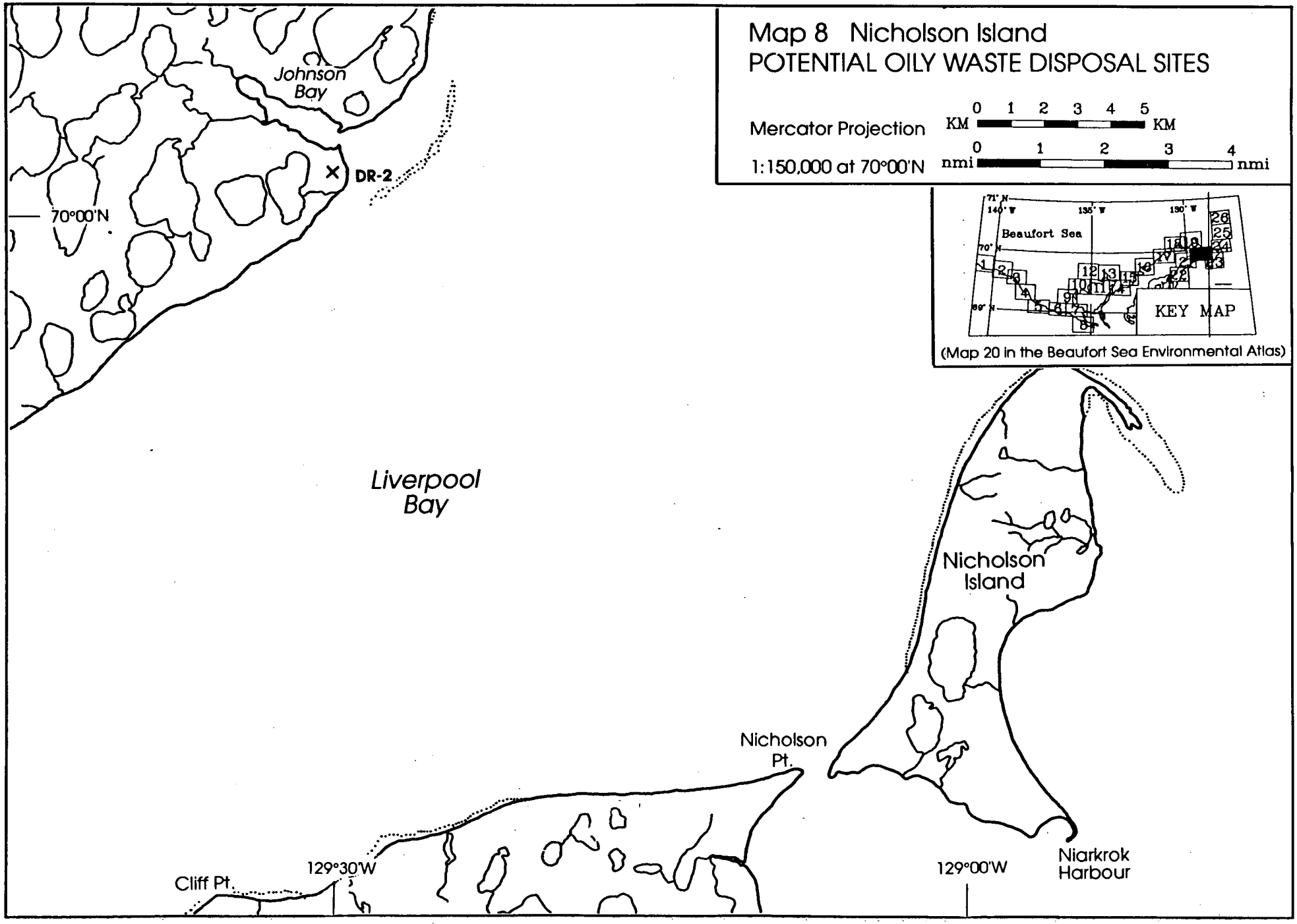
Crumbling Pt.

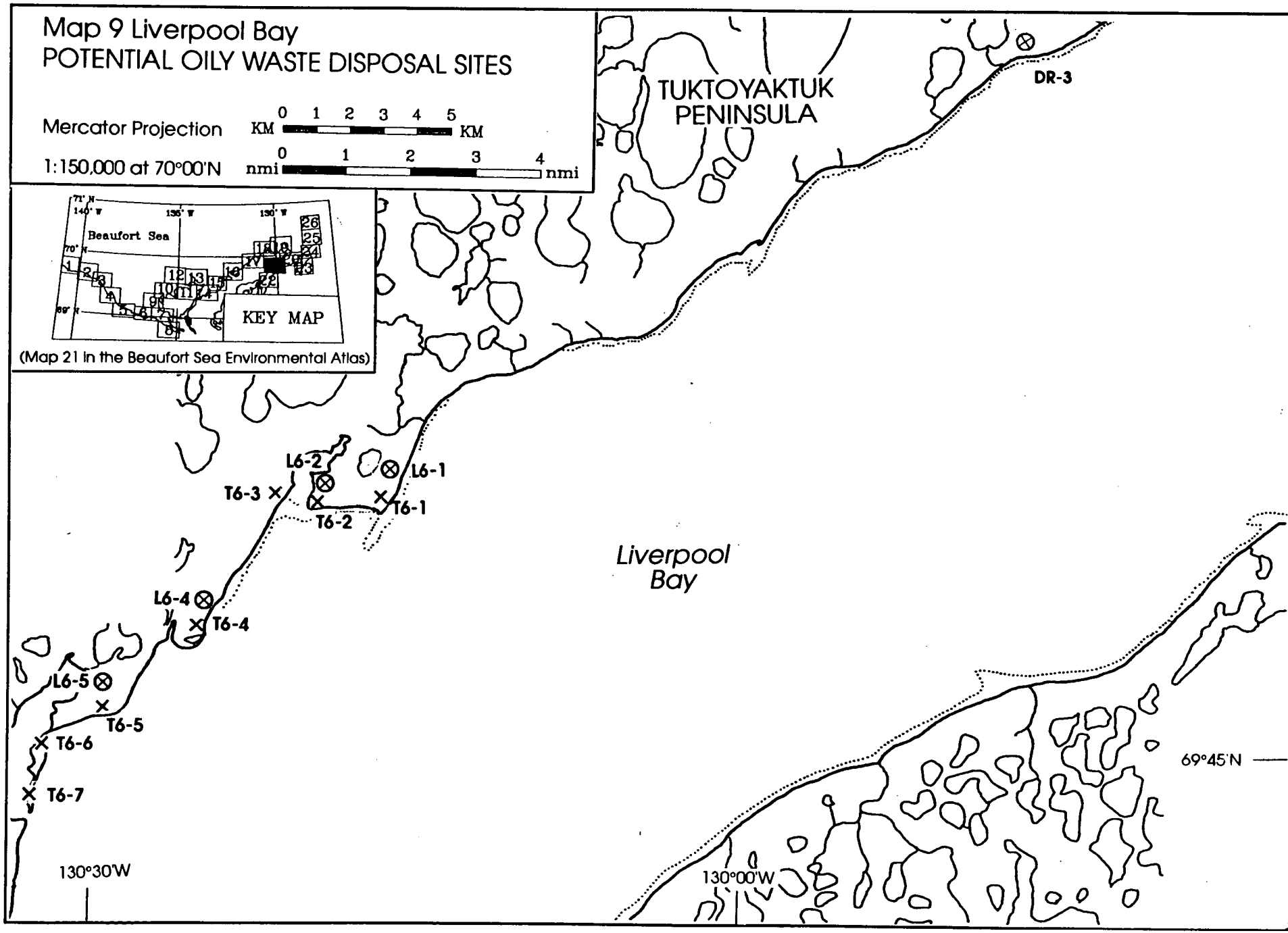
SUMMER ISLAND

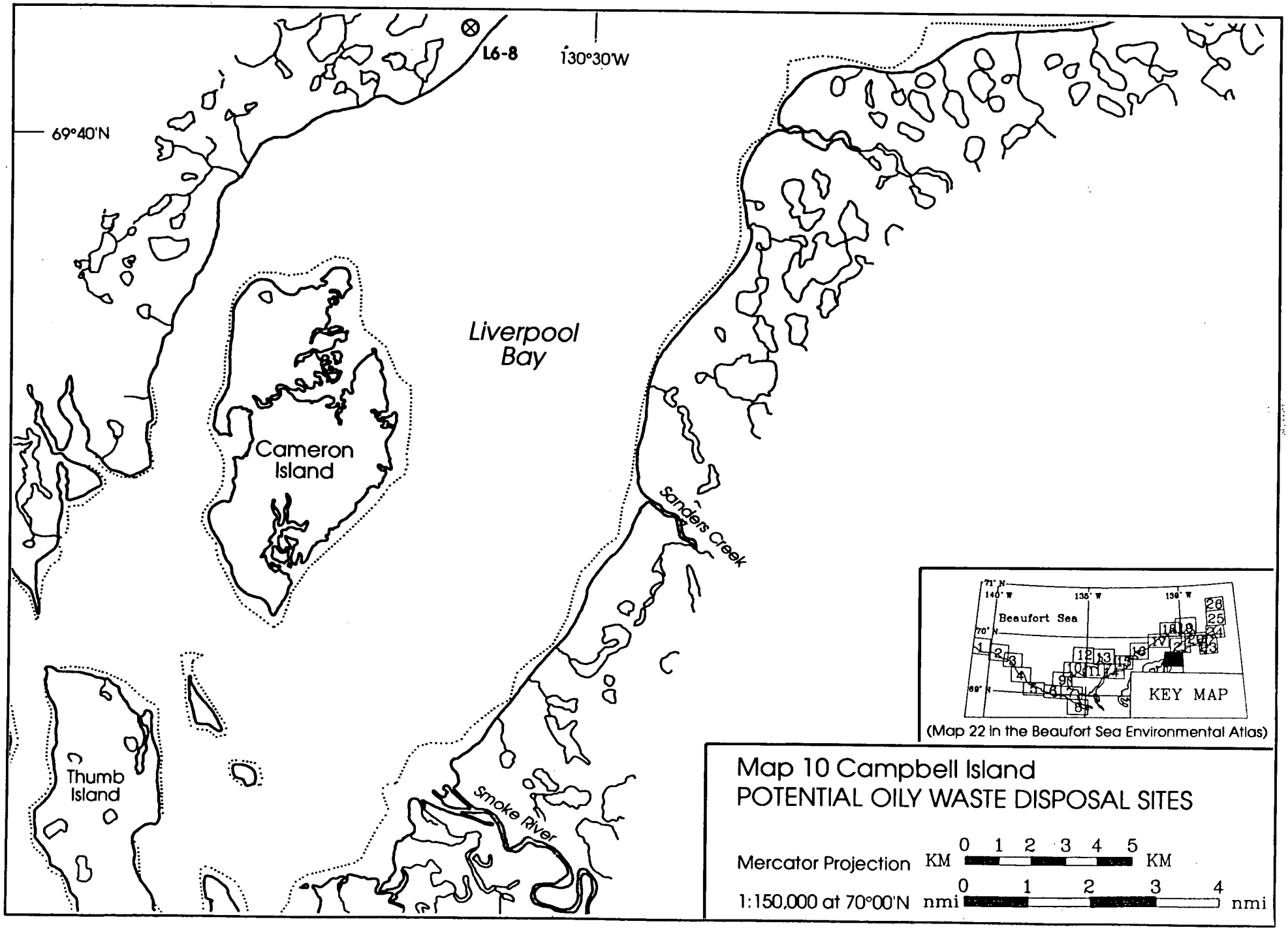

132°30'W
132°00'W
69°45'N
Beaufort Sea
KEY MAP
(Map 16 in the Beaufort Sea Environmental Atlas)
Warren Pt.
Hutchison Bay
Bols Pt.
Sakvalunat Pt.
L4-34
L4-33
T4-33
T4-32
L4-32
T4-31
Niuturuglak Peninsula
Toker Pt.
Mingnuk Pt.
Kukjuktuk Bay
Paaraluk Bay
Map 5 Hutchison Bay
POTENTIAL OILY WASTE DISPOSAL SITES
Mercator Projection
1:150,000 at 70°00'N
0 1 2 3 4 5 KM
0 1 2 3 4 nmi


131°00'W
130°30'W
70°15'N
Nuvorak Pt.
Relief Islet
Phillips Island
Seal Bay
Nuvorak Pt.
McKinley Bay
Seal Bay
Russell Inlet # 1
Beaufort Sea
KEY MAP
(Map 18 in the Beaufort Sea Environmental Atlas)
Map 6 Nuvorak Point
POTENTIAL OILY WASTE DISPOSAL SITES
Mercator Projection
0 1 2 3 4 5
KM
KM
1:150,000 at 70°00'N
0 1 2 3 4
nmi
nmi


Map 7 Cape Dalhousie
POTENTIAL OILY WASTE
DISPOSAL SITES
Mercator Projection
1:150,000 at 70°00'N
KM 0 1 2 3 4 5 KM
nmi 0 1 2 3 nmi
Beaufort Sea
KEY MAP
(Map 19 in the Beaufort Sea Environmental Atlas)
130°00'W
129°30'W
70°15'N
Cape Dalhousie
L4-60
DR-1
Russell Inlet # 3
Russell Inlet
Russell Inlet # 2
Cape Dalhousie East


Map 8 Nicholson Island
POTENTIAL OILY WASTE DISPOSAL SITES
Mercator Projection
1:150,000 at 70°00'N
0 1 2 3 4 5
KM
KM
0 1 2 3 4
nmi
nmi
Beaufort Sea
KEY MAP
(Map 20 in the Beaufort Sea Environmental Atlas)
Johnson Bay
DR-2
70°00'N
Liverpool Bay
Nicholson Island
Nicholson Pt.
Cliff Pt.
129°30'W
129°00'W
Niarkrok Harbour

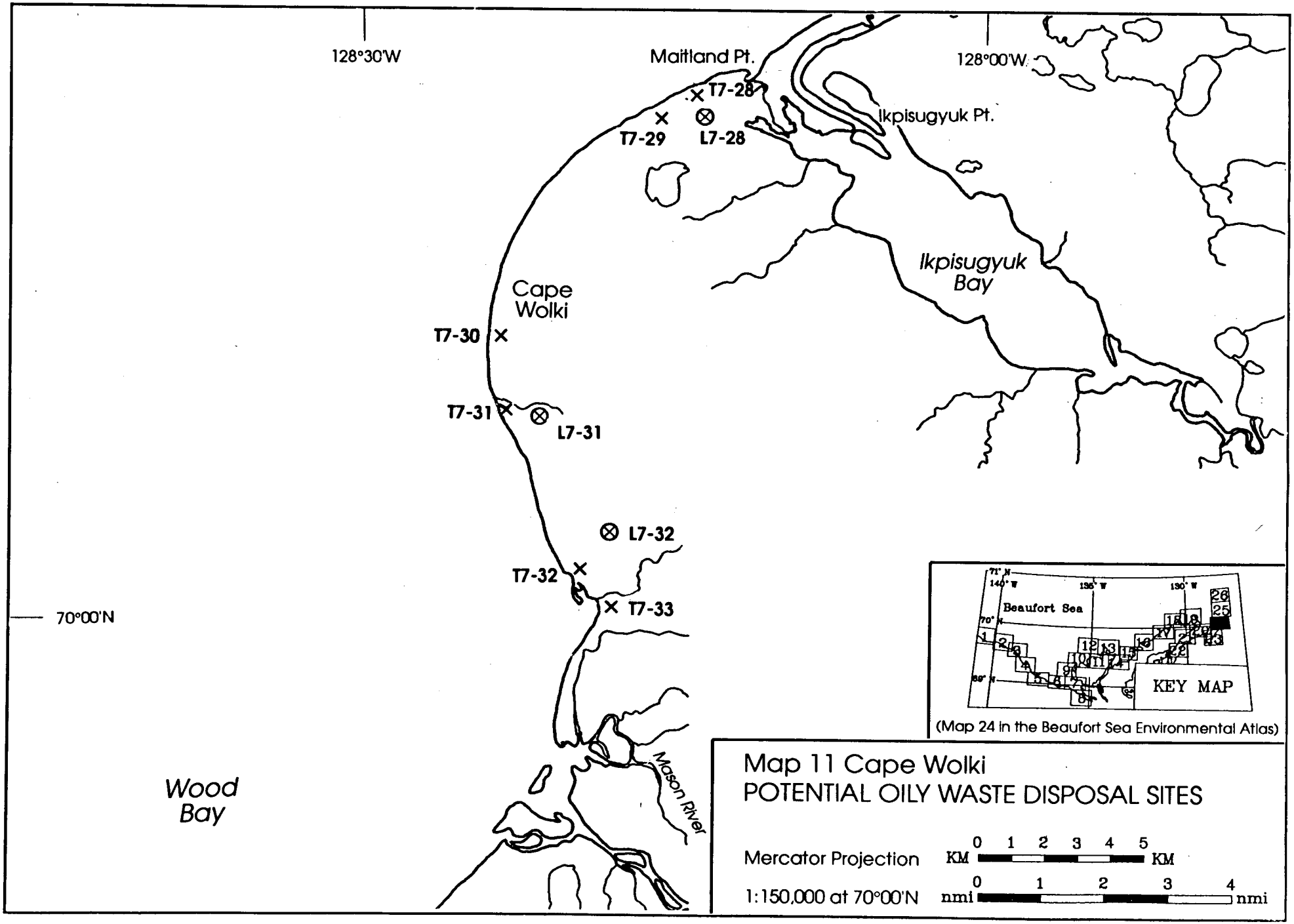

Map 9 Liverpool Bay
POTENTIAL OILY WASTE DISPOSAL SITES
Mercator Projection
1:150,000 at 70°00'N
0 1 2 3 4 5 KM
0 1 2 3 4 nmi
Beaufort Sea
KEY MAP
(Map 21 in the Beaufort Sea Environmental Atlas)
TUKTOYAKTUK PENINSULA
DR-3
L6-2
L6-1
T6-3
T6-2
T6-1
L6-4
T6-4
L6-5
T6-5
T6-6
T6-7
Liverpool Bay
69°45'N
130°30'W
130°00'W

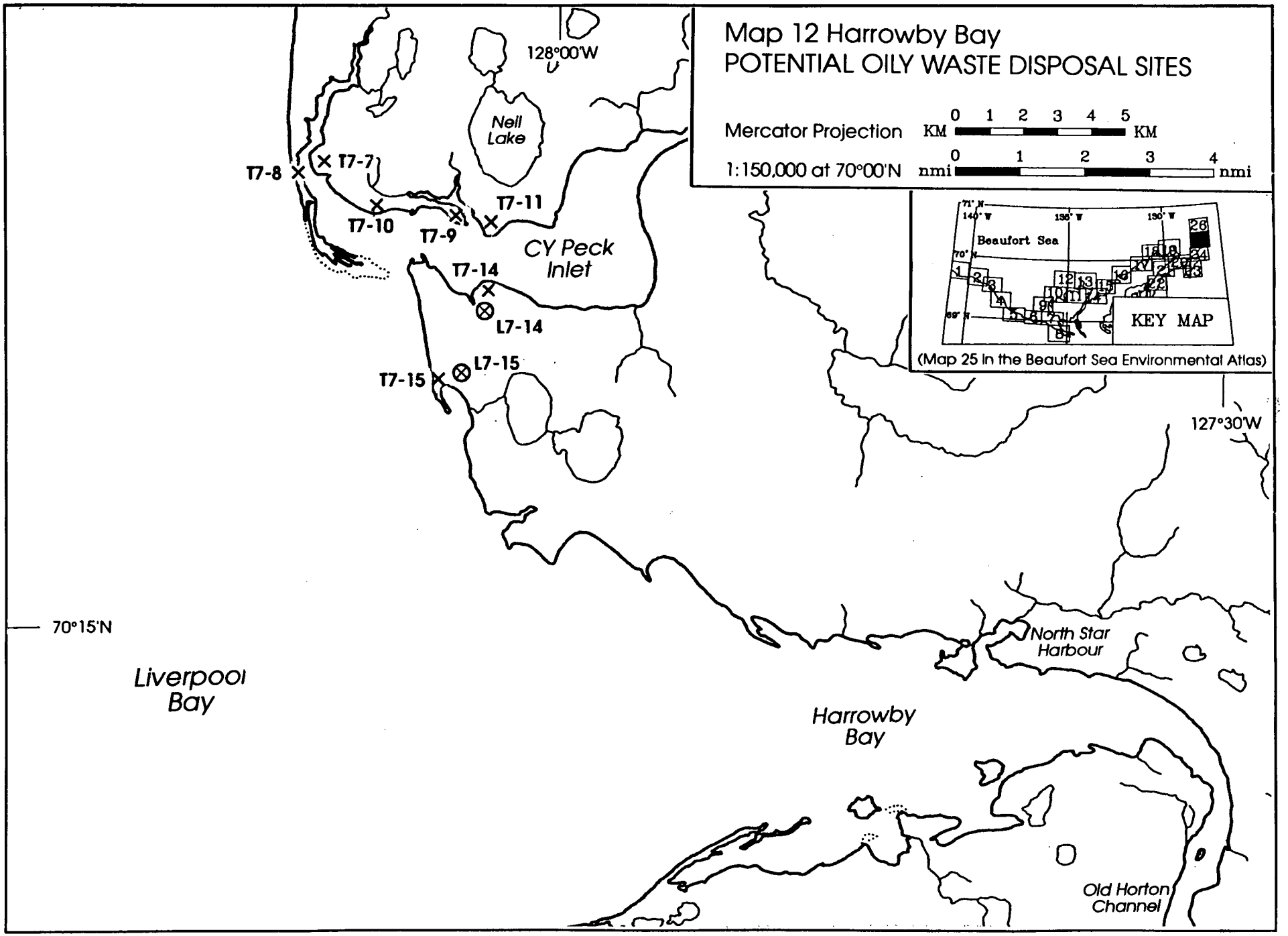


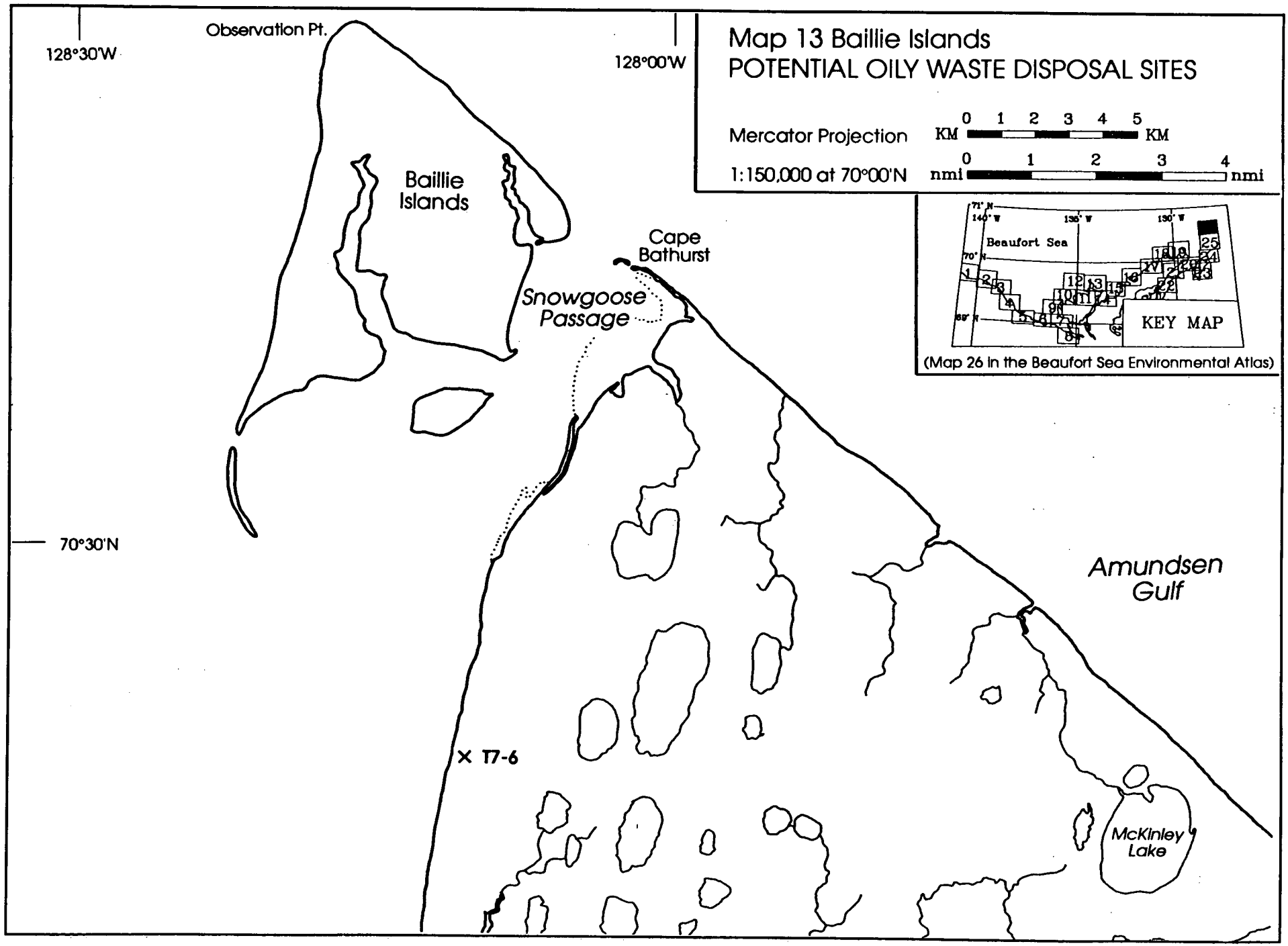

# Map 10 Campbell Island
## POTENTIAL OILY WASTE DISPOSAL SITES

Mercator Projection
0 1 2 3 4 5 KM

1:150,000 at 70°00'N
0 1 2 3 4 nmi


128°30'W
Maitland Pt.
128°00'W
T7-28
T7-29
L7-28
Ikpisugyuk Pt.
Ikpisugyuk Bay
Cape Wolki
T7-30
T7-31
L7-31
L7-32
T7-32
T7-33
70°00'N
Wood Bay
Mason River
Beaufort Sea
KEY MAP
(Map 24 in the Beaufort Sea Environmental Atlas)
Map 11 Cape Wolki
POTENTIAL OILY WASTE DISPOSAL SITES
Mercator Projection
1:150,000 at 70°00'N
0 1 2 3 4 5
KM
KM
0 1 2 3 4
nmi
nmi


Map 12 Harrowby Bay
POTENTIAL OILY WASTE DISPOSAL SITES
Mercator Projection
1:150,000 at 70°00'N
0 1 2 3 4 5 KM
0 1 2 3 4 nmi
128°00'W
Nell Lake
T7-8
T7-7
T7-11
T7-10
T7-9
CY Peck Inlet
T7-14
L7-14
T7-15
L7-15
Beaufort Sea
KEY MAP
(Map 25 in the Beaufort Sea Environmental Atlas)
127°30'W
70°15'N
Liverpool Bay
North Star Harbour
Harrowby Bay
Old Horton Channel

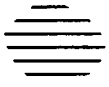

Map 13 Baillie Islands
POTENTIAL OILY WASTE DISPOSAL SITES
Mercator Projection
1:150,000 at 70°00'N
0 1 2 3 4 5
KM
KM
0 1 2 3 4
nmi
nmi
KEY MAP
(Map 26 in the Beaufort Sea Environmental Atlas)
Observation Pt.
128°30'W
128°00'W
Baillie Islands
Cape Bathurst
Snowgoose Passage
70°30'N
Amundsen Gulf
T7-6
McKinley Lake

# APPENDIX C

Summaries of Field Investigations for Each Site
(Including Air Photo Maps and Colour Photos)

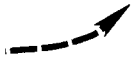
**Legend for the Air Photos Maps**

Sites favoured in terms of drainage, soils and terrain



Sites which have been indentified as being less favourable, but that should be considered if the more ideal sites are unavailable for use

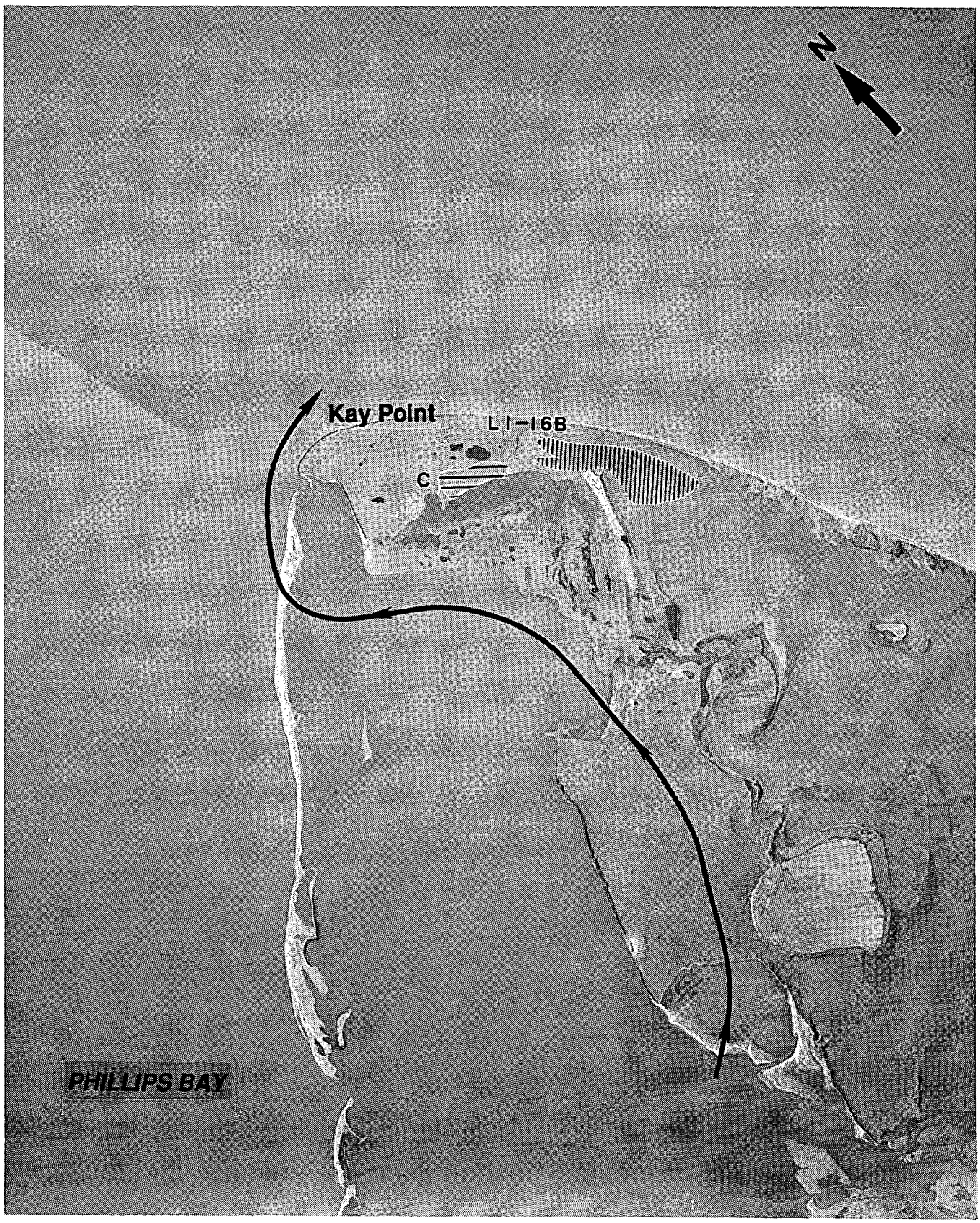
Route Flown While Videotaping



Marine and/or Land Access Route

**Index for Locating Site Descriptions and Maps in Appendix B**

## Kay Point: Sites L-16B, L-16 C



## Waste Storage Site **L1-16B**

| | |
|---|---|
| **Location:** | **Kay Point**, Yukon Coastal Plain<br>69.290°N, 138.367° W |
| **Maps** | Air Photo No. A26780 72<br>Hydrographic Chart No. 7661<br>NTIS 1:50,000 No. 117 D/6 |
| **I.L.A. Lands** | No |
| **Available Area:** | 120,000 $m^2$ |
| **Slopes and Drainage:** | Site slopes gradually at 1° to 2° to the southwest away from coast. Surface is moderately well-drained in spite of shallow active layer. Surface is marked by trenches 0.2 m deep by 0.4 m wide forming a 10 m diameter polygonal pattern; a few trenches are 0.4 m deep and 1.2 m across with standing water. The very southwestern edge of the site, adjacent to tidal flat, is extremely well-drained. |
| **Vegetative Cover:** | Mixture of tussocks of cottongrass and Ericales with a few prostrate willow and shrub birch. |
| **Surface Soils:** | Active layer is 0.2 m deep. Test pit shows peat with a trace of silt. An adjacent escarpment suggests that the peat is 0.2 to 0.3 m thick over most of site and underlain by approximately 0.3 m of silt. |
| **Geology:** | Site is underlain by glaciofluvial sands and gravels that border the southwest edge of the morainal ridge (the ridge at this site has been removed by coastal retreat). At the site 4 m of medium sand overlies 4 m of pebbly gravel. Sands and gravels are covered by silts that are commonly very icy. Ice wedges underlie the polygons. |
| **Access to Coast:** | Direct access to coast will be difficult because of actively eroding, steep 12 m coastal cliffs. Land access will require traversing slopes and narrow beach between the site and Kay Point, about 1400 m to west. Slopes are underlain by similar materials as the site, but one very small creek will require a crossing. |

**Coastal Retreat:** The coast has been reported to be actively retreating at an average rate of 1 m per year. Banks facing the Babbage River to the southwest of the site appear to be stable.

**Marine Access:** Barges may be able to approach the beach directly on the northeast side of the Point (the 5 m contour appears to come within hundreds of metres of the shore). High cliffs prevent any direct overland access to the inshore storage areas. Marine access is not possible to the north or along Kay Spit (the 5m depth contour is > 1 km offshore in this area). The overall assessment of marine access to this location is poor; the only possible landing area is exposed, with no protection from winds and waves.

**Borrow:** Ample silty and peaty fill are available at the site; however, it will require thawing and draining upon excavation. Sand is available, and if the site is excavated to depth, gravel will also be available. Otherwise, gravel can be obtained from Kay Point Spit or from pits at Shingle Point.

**Suitability:** Surface or in-ground storage is possible. In the case of surface storage, care will be required to insulate the icy peat and silt. If in-ground storage is contemplated, subsurface investigations will be needed to delineate and engineer ice-rich sediments and ice wedges. There is easy winter vehicle access from southwest; however, summer vehicle access will require the construction of an engineered road from Kay Point spit either across the tidal flats below the site, or over slopes to the west of the site. Colluvial and archeological features near Kay Point spit will require delineation so they can be avoided.

## Waste Storage Site **L1-16C**

| | |
|---|---|
| **Location:** | **Kay Point**, Yukon Coastal Plain<br>69.293°N, 138.383° W |
| **Maps** | Air Photo No. A26780 72<br>Hydrographic Chart No. 7661<br>NTIS 1:50,000 No. 117 D/6 |
| **I.L.A. Lands** | No |
| **Available Area:** | 19,000 $m^2$ (457 m by 305 m triangle). |
| **Slopes and Drainage:** | The site consists of a broad flat area that gently slopes to the southwest. Trenches up to 1 m deep and 2 m wide form polygons with 8 to 12 m diameters. There is standing water in some of the polygons. Most of area is moderately well-drained. |
| **Vegetative Cover:** | Mainly Ericales and shrub birch; sedges, grasses (other herbs ande prostrate willow also present) |
| **Surface Soils:** | The active layer was 0.4 m deep on August 11. The test pit showed that there is 0.15 m of peat over 0.27 m of organic silt. |
| **Geology:** | The site consists of a layer of silt underlain by glaciofluvial sands and gravels up to 8 m in thickness. The silts and surface peat may be icy. Polygons indicate an extensive ice wedge network under the site. |
| **Access to Coast:** | Direct access to the coast will be difficult because of steep eroding cliffs, 10 m high, and a wet basin between the site and the coast. Land access will require traversing slopes and a narrow beach between the site and Kay Point, which is about 1000 m west of the site. The slopes are underlain by similar materials to the site, with one very small creek to cross. |
| **Coastal Retreat:** | The coast has been reported to be actively retreating at an average rate of 1 m per year. Banks facing the Babbage River to the southwest of the site appear to be stable. |
| **Marine Access:** | See comments regarding L1-16B. |

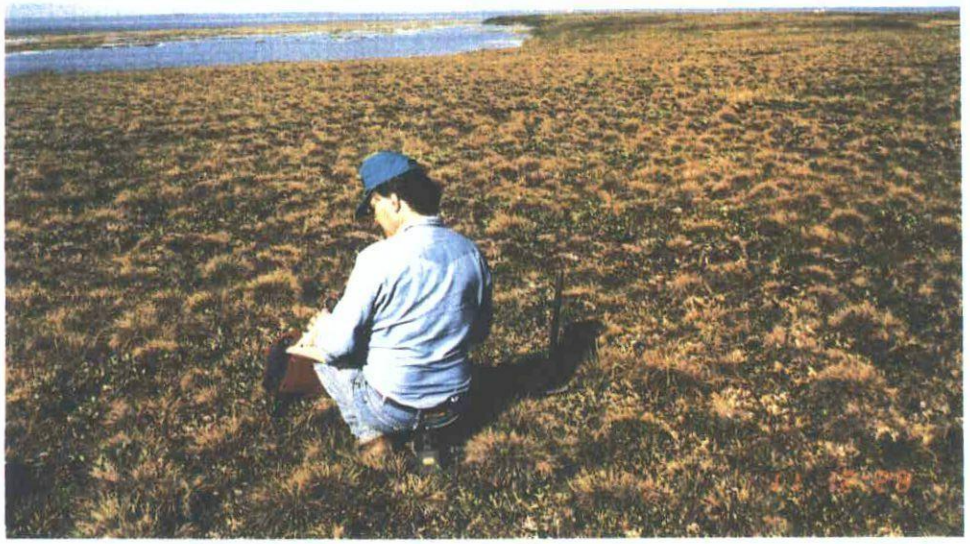
**Borrow:**

Ample silty and peaty fill are available at the site; however, it will require thawing and draining upon excavation. Sand is available, and if the site is excavated to depth, gravel will also be available. Otherwise, gravel can be obtained from Kay Point spit or from pits at Shingle Point.

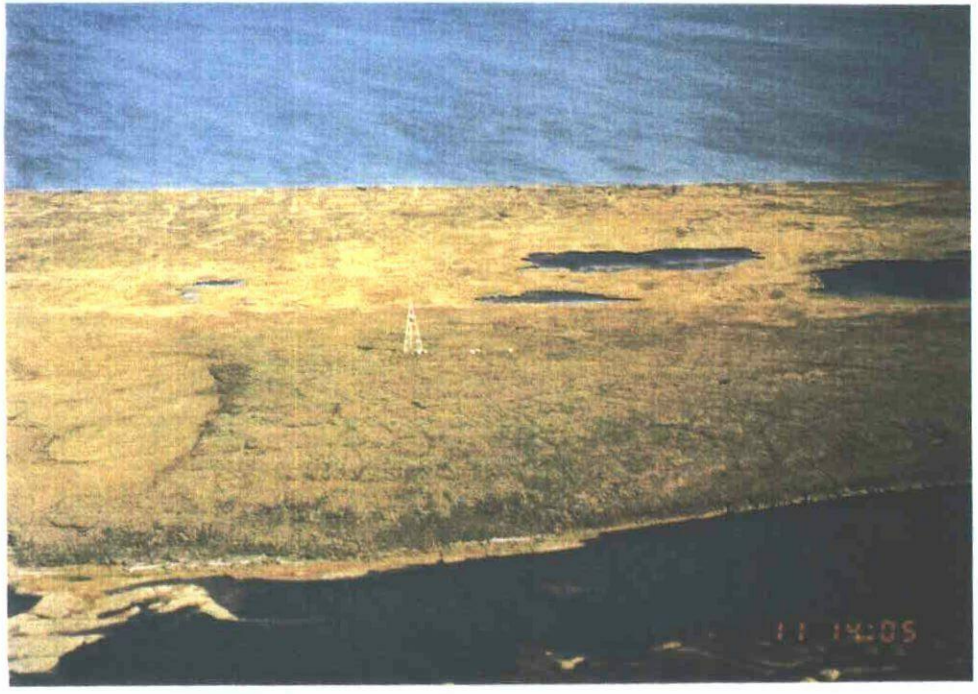
**Suitability:**

Surface or in-ground storage is possible. In the case of surface storage, care will be required to insulate the icy peat and silt. Some leveling of the site may be required to separate the waste from underlying materials. If in-ground storage is contemplated subsurface investigations will be needed to delineate and engineer ice-rich sediments and ice wedges. There is easy winter vehicle access from southwest; however, summer vehicle access will require the construction of an engineered road from Kay Point spit either across the tidal flats below the site, or over slopes to the west of the site. Archeological features near Kay Point spit will require delineation so they can be avoided.

Aerial View of Kay Spit from the Northwest



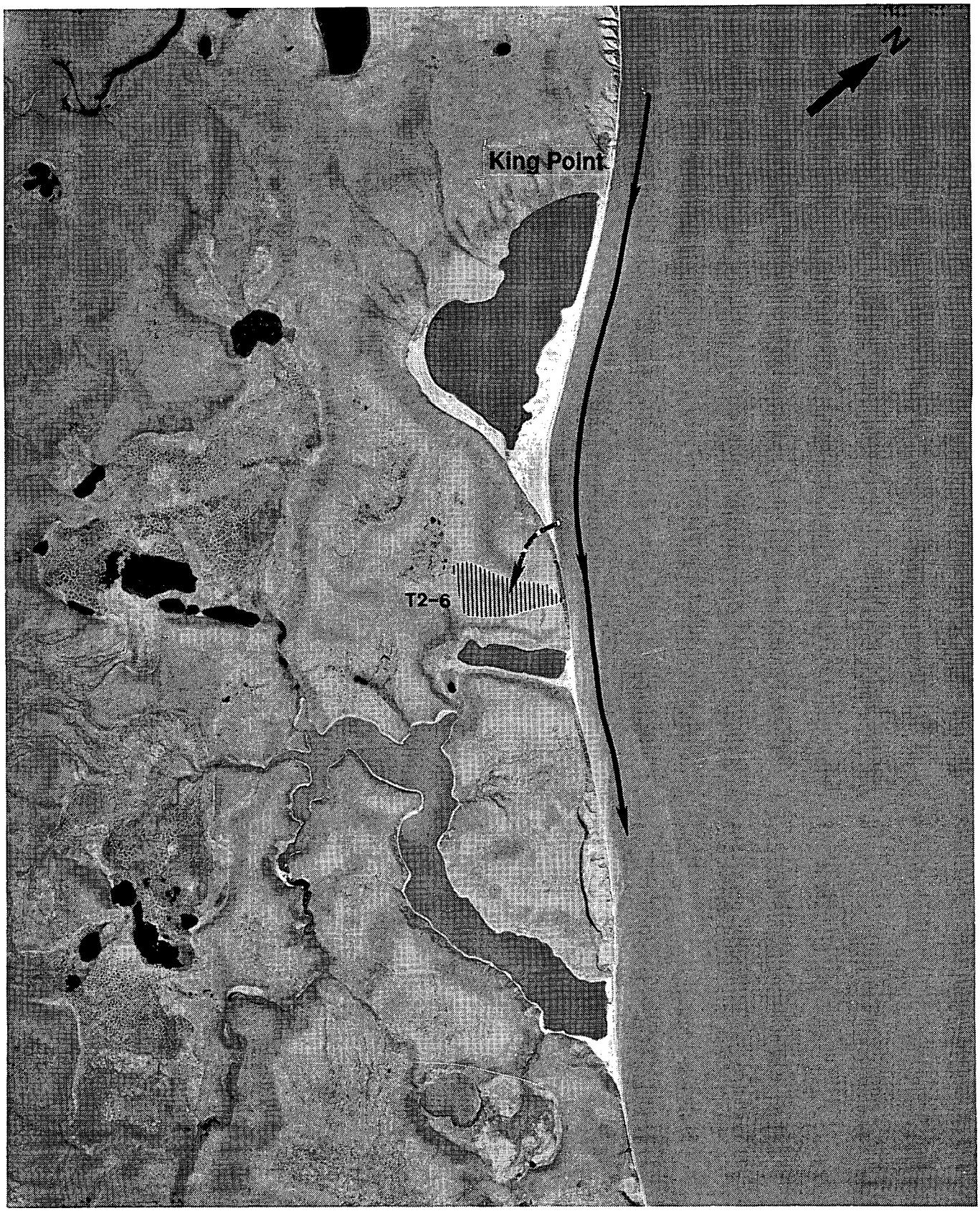
General View of Site L1-16B North to Kay Point Spit



Aerial View of Site L1-16C from the Southwest

View Northwest Along Kay Point Cliffs

## King Point: Site T2-6



## Waste Storage Site **T2-6**

| | |
|---|---|
| **Location:** | **King Point**, Yukon Coastal Plain<br>69.093°N, 137.950° W |
| **Maps** | Air Photo No. A26779 10<br>Hydrographic Chart No. 7661<br>NTIS 1:50,000 No. 117 D/2 |
| **I.L.A. Lands** | No |
| **Available Area:** | 110,000 $m^2$ (228 m by 486 m). |
| **Slopes and Drainage:** | The site is flat to gently-sloping from crest to flanking slopes and the ocean. The site is moderately well-drained in spite of a shallow active layer. There is no obvious polygonal pattern on the surface. |
| **Vegetative Cover:** | The site is completely covered with tussocks of cottongrass, Ericales and the rare prostrate shrub birch. |
| **Surface Soils:** | The active layer was 0.35 m thick on August 11. A test pit showed 0.25 m of peat over organic silt. |
| **Geology:** | Multiple levels at the site represent cyclic thermokarst lake development. Lacustrine clays and silts under surface peats overlie glacial till. This sequence is verified by the sequence shown in the coastal cliffs, and drill logs of a nearby area which show 1 to 3 m of peat and ice over 2 to 6 m of very ice-rich silt and ice over 6 to 8 m of till. |
| **Access to Coast:** | Direct coastal access will be difficult due to a retrogressive thaw flow slide at the coast. This flow slide forms part of an 18 m escarpment at the coast. Access is best by the gentle slope at the east end of King Point spit, 300 m away. At end of the spit a 5 m bank rises at 10° angle above the spit surface. The spit is over 150 m wide and covered with driftwood. |
| **Coastal Retreat:** | Coastal retreat is progressing through retrogressive thaw flow slides and wave erosion. Reported rates of coastal retreat for this site vary between 2.4 m/year and 3.1 m/year. |

**Marine Access:** It should be possible to dry ramp oiled debris directly onto the beach south of King Point with convenient low bank access to the site across a band of driftwood and log debris. The barge landing point is exposed with no protection against swells and winds from the east or northeast. Marine access at this site would be highly weather dependent.

**Borrow:** Silt and peaty fill are available at the site, but will require thawing and draining following excavation. Sand and gravel is available from King Point spit or from pits at Shingle Point.

**Suitability:** Surface or in-ground storage is possible, but in-ground storage will be complicated by the very icy nature of the upper 4 to 6 m of underlying sediment. For in-ground storage, special care will be needed to excavate, thaw, and drain sediments. Surface storage will require special care to prevent the melting of underlying sediments and the initiation of thermokarsts. Winter vehicle access will be easy, but summer access will require an engineered road approximately 300 m long to King Point spit.

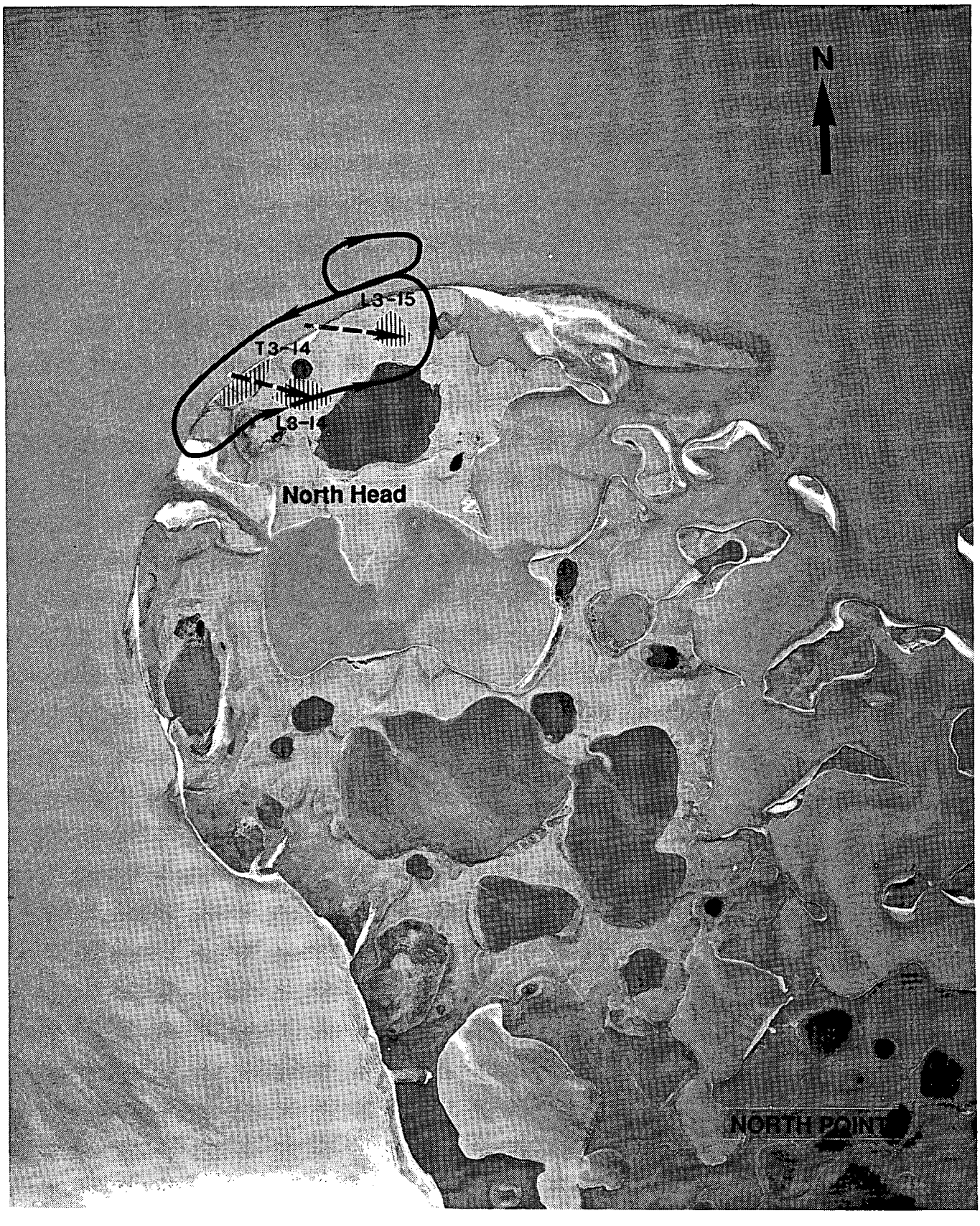
Aerial View of Site T2-6 from the West

Aerial view of Site T2-6 and the Southern Portion of the King Pt. Spit

View of Site T2-6 Northwest to King Pt. Spit

Pit at Site T2-6

## North Head: Sites L3-14, L3-15, T3-14



Waste Storage Site **L3-14**

| | |
|---|---|
| **Location:** | **North Head,** North Point, Richards Island<br>69.717° N, 134.453°W |
| **Maps** | Air Photo No. A22974-98<br>Hydrographic Chart No. 7663, 7662<br>NTIS 1:50,000 No. 107 C/11 |
| **I.L.A. Lands** | No |
| **Available Area:** | 32,000 $m^2$ (113 m by 284 m); less desirable area (50,000 $m^2$ or greater) available to southeast for expansion. |
| **Slopes and Drainage:** | The site slopes gently to the southeast and is well-drained. The surface is characterized by irregular hummocks and a few bare inactive frost boils. Shallow narrow trenches form polygons approximately 10 m in diameter. The potential expansion area in the southeast has larger trenches up to 1 m deep and 2 m wide. |
| **Vegetative Cover:** | The site is 95% to 100% covered in vegetation. There is a mixture of sedges, Ericales and other herbs, and a few prostrate shrub willows. Ground cover in the southeastern region is complete, with sedges dominating. |
| **Surface Soils:** | The active layer was 0.4 m on August 7 in the main site and 0.3 m in the area to the southeast The thawed material consisted mainly of organically-rich silty fine sand. |
| **Geology:** | Regionally, the upland area is mapped as consisting of till veneered marine sands. Coastal exposures indicate that up to 0.5 m of organic-rich silty sandy colluvium overlies at least 12 m of fine sandy silt and fine sand. Excess ice content commonly appears to be 5% to 15%, but at the top of the permafrost there is a zone of excess ice , 70% by volume. Ice wedges under polygon trenches were present at approximately 10 m intervals. |

| | |
|---|---|
| **Access to Coast:** | Direct access is easy over 280 m of gentle slopes and a flat basin to a narrow driftwood-covered beach. The beach is sandy, firm and narrow. |
| **Coastal Retreat:** | The coast is retreating at the access point through wave erosion and slumping at a reported average rate of 2.2 m/year. |
| **Marine Access:** | Charts indicate that direct access to the beach may be possible with barges drawing less than 2 m. Caution is advised in approaching from the east as minimum depths of 1 to 1.5 m are reported between the Pullen Island spit and North Point. |
| **Borrow:** | The site will provide fine fill and an adequate amount of material for revegetated cover. Undoubtedly, much of the volume will be lost from material excavated below the active layer due to excess ice. Sand and gravel is available locally in any quantity from a large spit 2500 m east of the site. |
| **Suitability:** | Surface or in-ground storage is possible. There is easy winter vehicle access, but summer access will require an engineered road to be constructed along the access route to prevent thaw and erosion. Engineering may also be required to maintain drainage along polygon trenches in the southeastern extension of the site. |

## Waste Storage Site **L3-15**

| | |
|---|---|
| **Location:** | **North Head**, North Point, Richards Island<br>69.722° N, 134.530° W |
| **Maps** | Air Photo No. A22974-98<br>Hydrographic Chart No. 7663, 7662<br>NTIS 1:50,000 No. 107 C/11 |
| **I.L.A. Lands** | No |
| **Available Area:** | 90,120 $m^2$. (227 m by 397 m); some area available to the east for possible expansion. |
| **Slopes and Drainage:** | Most of the site slopes gently to the east with a maximum slope of 2°. The site is well-drained and the surface is characterized by irregular hummocks, some of which are arranged in poorly-developed, striped patterns. There are also a few bare inactive frost boils. Shallow, narrow trenches form polygons 10 m in diameter. |
| **Vegetative Cover:** | 95 to 100% of the site is vegetated. There is a mixture of sedges, Ericales and other herbs, and a few prostrate shrub willows. |
| **Surface Soils:** | There was an active layer of 0.45 m on August 7. The thawed materials consisted mainly of dry organically-rich silt. |
| **Geology:** | Regionally, the upland area is mapped as till veneered marine sands. The coastal exposure indicates that up to 0.5 m of organically-rich silty sandy colluvium overlies at least 12 m of fine sandy silt and fine sand. The excess ice content appears to be commonly 5% to 15% volume, but at the top of the permafrost layer there is a zone of excess ice which is 70% by volume. Ice wedges under the polygon trenches are present at approximately 10 m intervals. |
| **Access to Coast:** | Direct access to the coast is inhibited by steep cliffs 10 to 15 m in height marked by retrogressive thaw flow slides and active slumps. Four hundred metres to the west, across a well-drained, moderately-gentle slope, is a low bench with a large amount of driftwood. The beach is sandy, firm and narrow. |

**Coastal Retreat:** The coast is retreating through wave erosion and slumping and retrogressive thaw flow slides at a reported average rate of 1.3 m/year.

**Marine Access:** See preceding comment for L3-14.

**Borrow:** The site will provide fine fill and an adequate material for revegetated cover. Undoubtedly, much of the volume will be lost from the material excavated below the active layer due to excess ice. Sand and gravel are locally only available, in any quantity, from a large spit, 1100 m east of the site.

**Suitability:** Surface or in-ground storage is possible at the site. There is easy vehicle winter access, but summer access would require an engineered road to be constructed along the access route to prevent thaw and erosion.

Waste Storage Site **T3-14**

| | |
|---|---|
| **Location:** | **North Head,** North Point, Richards Island<br>69.717°N, 134.472° W |
| **Maps** | Air Photo No. A22974-98<br>Hydrographic Chart No. 7663, 7662<br>NTIS 1:50,000 No. 107 C/11 |
| **I.L.A. Lands** | No |
| **Available Area:** | 48,000 $m^2$, although a 20 m buffer zone along the coast will remove 10,000 $m^2$ of the area. |
| **Slopes and Drainage:** | The site is flat with an imperceptible slope towards the ocean. There are no obvious periglacial patterns and the drainage is through a slow seepage across the depression. The site was moderately dry on August 7 with only a few damp areas. |
| **Vegetative Cover:** | The site 100% vegetated with a full cover of sedges. |
| **Surface Soils:** | The active layer was 0.35 m thick on August 7. The thawed materials consisted of silt and sand with a highly organic content in the upper part of the layer. |
| **Geology:** | The basin is underlain by lacustrine silt and fine sand. Because the basin is thermokarst in origin, no massive ice is expected to underlie the site. However, coastal exposures indicate excess ice contents of 5% to 15% in lacustrine sediments. Ice wedges are probably present under the basin, but they are expected to be smaller than in the surrounding uplands. |
| **Access to Coast:** | Most of the site is bordered by 3 m to 4.5 m high actively eroding escarpement on the ocean side. But at the centre of the site, there is a basin with gentle slopes leading to a 2 m high stabilized slope, which leads to a driftwood-covered sandy, firm, narrow beach. |
| **Coastal Retreat:** | The coast is retreating at the access point through wave erosion and slumping at a reported average rate of 2.2 m/year. |

**Marine Access:** See preceding comment for L3-14.

**Borrow:** The site will provide fine fill and an adequate amount of material for revegetated cover. Undoubtedly, much of the volume will be lost from material excavated below the active layer due to excess ice. Sand and gravel is only available locally in any quantity from a large spit 2500 m east of the site.

**Suitability:** Surface or in-ground storage is possible, although in-ground storage would only be advisable on the inland part of the site due to rate of coastal retreat. The position of the storage area would be governed by length of time required for storage and the rate of coastal retreat. Care will be required so as not to inhibit the drainage of the surrounding slopes across the basin to the ocean. There is easy winter vehicle access, but summer access will require a short road to prevent thaw and erosion.

Aerial View of Site T3-14 from the Northwest

Aerial View of Site L3-14 from the North

Site L3-14

Pit at Site L3-14

View of Low Bank Shoreline at Site T3-14

Pit at Site T3-14

Aerial View from the Northwest of Site L3-15 and Access Route

View of Access Point for Site L3-15

## Hadwen Island: Site DR-4

Waste Storage Site **DR-4**

| | |
|---|---|
| **Location:** | **Hadwen Island**, northern Richards Island<br>69.600° N, 134.030° W |
| **Maps** | Air Photo No. A22974-82<br>Hydrographic Chart No. 7663, 7662<br>NTIS 1:50,000 No. 107 C/11 |
| **I.L.A. Lands** | No |
| **Available Area:** | Area A - 80,000 $m^2$; Area B - 300,000 $m^2$; Area C - 200,000 $m^2$. |
| **Slopes and Drainage:** | The site has a gently rolling surface with a maximum relief of 8 m, although the relief is generally less than 3 m. The slopes are very gentle, rarely greater than 5°. The surface of the broad knolls and ridges are very well-drained with no obvious polygonal pattern. The surfaces of the swales are moderately well-drained, but marked by polygons 6 m in diameter. Trenches are up to 0.5 m deep and 1.2 m across. |
| **Vegetative Cover:** | The knolls and ridges are 95% covered by a mixture of grasses, *Dryas* and other herbs, and a few prostrate willows. The swales have a continuous cover (100%) of sedges, *Dryas*, and a few willows. |
| **Surface Soils:** | The active layer on the knolls and ridges was 0.9 m deep on August 11 and 0.6 m in the swales. On the knolls, fine medium sand has involuted organic layers to a depth of 0.5 m. In the swales, peat, with a depth greater than 0.15 m, overlies silty fine sand to a depth of least 0.6 m. |
| **Geology:** | Regionally, the area is mapped as consisting of till-veneered sands; however, till does not appear to be present on island's surface (only one large erratic was noted on tidal flat). Coastal exposures show over 8 m of fine brown sand. The sand appears to be dry, but the upper 2 to 3 m may contain significant excess ice. |
| **Access to Coast:** | Direct access to coast is easy over well-drained slopes and low banks. The beaches are narrow and sandy with a pebbly lag. |

**Coastal Retreat:** Most escarpments around island appear to be moderately stable. Slopes are generally covered by vegetated clods of sand, but some active sloughing is present. The average reported annual rate of retreat ranges from 0 m/year to 0.75 m/year.

**Marine Access:** Marine access through the channel between Hadwen Island and Summer Island is tricky but possible with drafts up to 2 m (following a narrow channel near Summer Island). Depths immediately off the SE shore of Hadwen Island are not known. Direct barge access to the beach is unlikely.

**Borrow:** A limited amount of fine fill will be available from the swales for revegetated cover; however, much of the fine sand required will be available . No local sources of gravel are readily available.

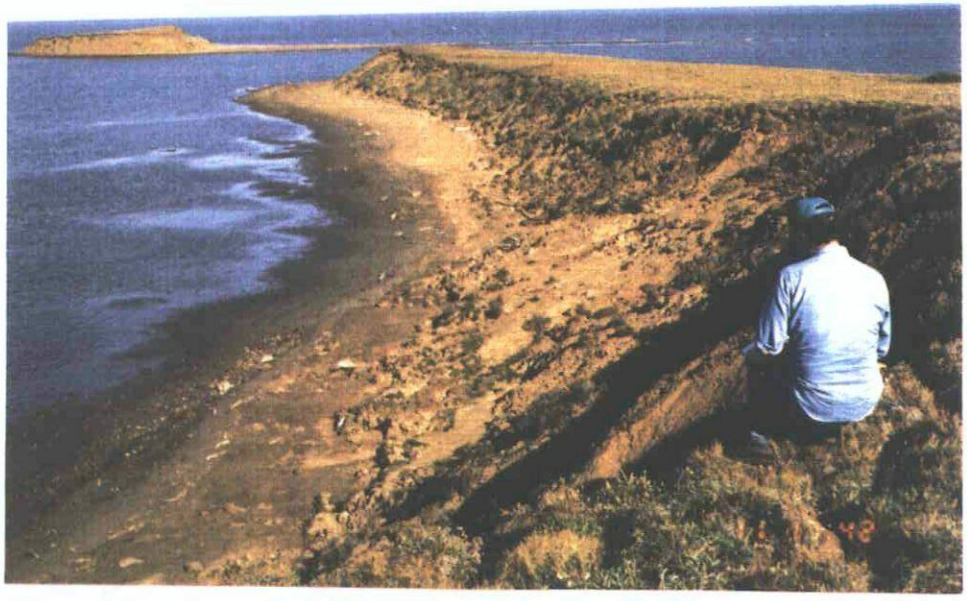
**Suitability:** Surface or in-ground storage is possible. There is easy winter vehicle access, but summer vehicle access will require a short road to prevent thaw and erosion.

A well was drilled on the island. The site has been abandoned and rehabilitated with sand; the previous drilling pad appears to be stable, although largely unvegetated.

Aerial View of Site DR-4 from the Southwest

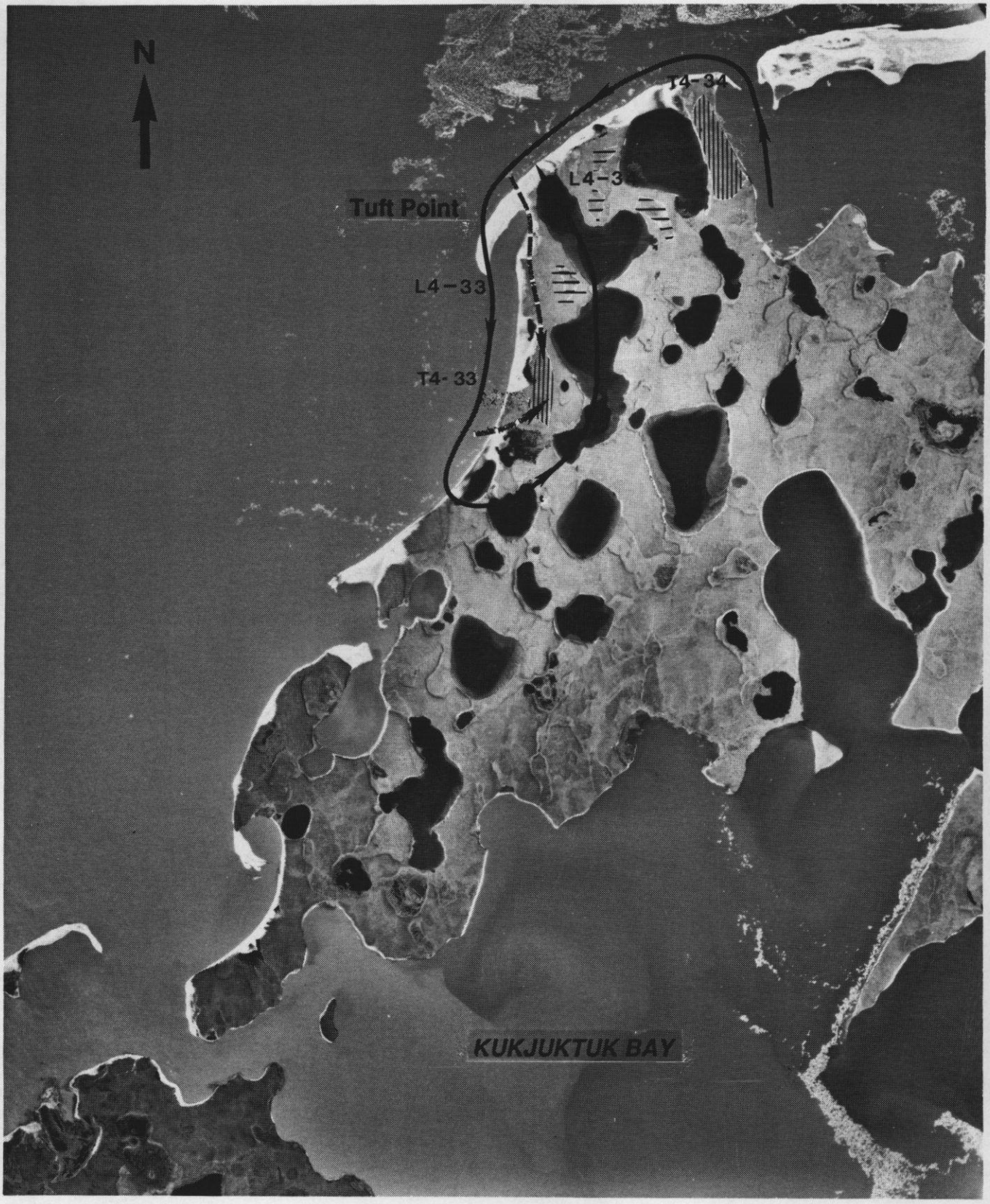
Aerial View of Site DR-4(A) from the East

General View of Site DR-4 (A) from the southwest



View of Shoreline at Site DR-4(A) on the Northwestern Tip of Hadwen Is.

## Tuft Point: Sites T4-33, T4-34, L4-33, L4-34



Waste Storage Site **T4-33**

| | |
|---|---|
| **Location:** | **Tuft Point**, Tuktoyaktuk Peninsula<br>69.711°N, 132.552° W |
| **Maps** | Air Photo No. A22884-205<br>Hydrographic Chart No. 7663<br>NTIS 1:50,000 No. 107 C/9 |
| **I.L.A. Lands** | Yes |
| **Available Area:** | 70,000 $m^2$ (irregular shape, 284 m by 110 m and 340 by 114 m). |
| **Slopes and Drainage:** | The site forms a bowl that slopes gently towards a pond by the coastal dunes. The site is well to moderately well-drained except near the pond where drainage is imperfect. Polygons are poorly developed, in general, with narrow trenches less than 0.3 m deep and 0.3 m wide; there are a few, however, that are 0.6 m deep and 1.5 m wide. |
| **Vegetative Cover:** | Along the upper edge of the bowl, 20% of the area is free of vegetative cover. Towards the centre of the bowl, the vegetation is more continuous and consists mainly of sedges. |
| **Surface Soils:** | The active layer was 0.55 m in the well-vegetated portion of the bowl on August 8. The outer edge of the bowl is underlain by fine medium sands and the centre of the bowl is underlain by clayey silt with the upper 0.15 m being organicly-rich. |
| **Geology:** | The site is located on the remnant of a broad outwash plain. Subsequent to this deposition, ground ice within the sediments has thawed to form thermokarst depressions and lakes. Some silt has accumulated in the depression. Ground ice is present in the form of ice wedges and segregated ice lenses. Some massive ice may be present at depth, but it is probably absent from under the lower part of the bowl. Local exposures show over 15 m of fine to medium sand. |
| **Access to Coast:** | Direct access to the coast is available across a 30 m wide strip of partially stabilized sand dunes. The beach is narrow, sandy and firm. |

**Coastal Retreat:** The coast appears to be relatively stable in this region with 6 m high, partially-vegetated banks to the north of the access point. The average reported coastal retreat in this vicinity is 0.17 m/year.

**Marine Access:** Charts indicate that the 5 m contour approaches within a few hundred metres of the west-facing shore adjacent to T4-33 (possible approach indicated by arrow on the air photo).

**Borrow:** There is a limited amount of silty fill available for cover and revegetation in the swales. Sandy borrow can be obtained from the site and the nearby beach. There are no good local sources of gravel available.

**Suitability:** Surface or in-ground storage is possible at the site. Subsurface investigations will be required to locate and engineer the ice-rich sediments and massive ice where present, especially in the case of in-ground storage. Engineering may also be required in the lower part of the bowl to prevent thaw disturbance. There is easy winter vehicle access, but a short road will be required for summer access to prevent thaw and erosion.

Waste Storage Site **L4-33**

| | |
|---|---|
| **Location:** | **Tuft Point**, Tuktoyaktuk Peninsula<br>69.720°N, 132.542° W |
| **Maps** | Air Photo No. A22884-205<br>Hydrographic Chart No. 7663<br>NTIS 1:50,000 No. 107 C/9 |
| **I.L.A. Lands** | Yes |
| **Available Area:** | 190,000 $m^2$ (568 m by 340 m). |
| **Slopes and Drainage:** | The site consists of a broad hill that gently slopes to the lakes to the east and the swale paralleling the ocean shoreline to the west (a ridge lies between the swale and the shoreline). Most of the hill is marked by trenches up to 1.5 m deep and 2.0 m across forming a polygonal pattern with a 12 m to 15 m diameter. Some of the trenches have elevated rims. The site is well-drained with the exception of the trenches which are moderately well to imperfectly drained. |
| **Vegetative Cover:** | The surface of the site is 15% vegetation-free and is characterized by small hummocks. The vegetative mixture consists of sedges, herbs and shrub birch. |
| **Surface Soils:** | On the well-drained hill, the active layer was 0.85 m thick on August 8. For most of the site, 0.2 m of organicly-rich sand overlies 0.65 m of medium-fine sand. The surface materials are silty in the swale. |
| **Geology:** | The site is located on the remnant of a broad outwash plain. Subsequent to this deposition, ground ice within the sediments has thawed to form thermokarst depressions and lakes. Some silt has accumulated in the depression. Ground ice is present in the form of ice wedges and segregated ice lenses. A well-developed polygonal pattern, similar to that present at this site, often indicates massive ice at depth. Local exposures show over 15 m of fine medium sand. |

| | |
|---|---|
| **Access to Coast:** | Direct access to the coast from the site is prevented by a ridge with a 9.5 m escarpment on its ocean side. However, the coast can be easily accessed by a route which follows the gentle slopes at the south end of site and crosses the partially-stabilized dunes to the narrow sandy beach. |
| **Coastal Retreat:** | Turf on the steep bank facing the ocean indicates that the shoreline is relatively stable. The spit attached to west end of Tuft Point may protect the coastline during storms. The average reported coastal retreat at this site is 0.17 m/year. |
| **Marine Access:** | Nearest access would be through T4-33 to the south. |
| **Borrow:** | There is a limited amount of silty fill available for cover and revegetation in the swales. Sandy borrow can be obtained from the site and the nearby beach. There are no good local sources of gravel available. |
| **Suitability:** | Surface or in-ground storage is possible at this site. If surface storage is used, site leveling involving the filling of trenches will be required to keep waste material from possibly seeping downslope along the trenches. Subsurface investigations will be required to locate and engineer ice-rich sediments and massive ice where present. There is easy vehicle access in the winter along the selected route at the south end of site, but a short road will be required for summer access to prevent thaw and erosion. |

Waste Storage Site **L4-34**

| | |
|---|---|
| **Location:** | **Tuft Point**, Tuktoyaktuk Peninsula<br>69.728° N, 132.527° W |
| **Maps** | Air Photo No. A22884-205<br>Hydrographic Chart No. 7663<br>NTIS 1:50,000 No. 107 C/9 |
| **I.L.A. Lands** | Yes |
| **Available Area:** | 160,000 $m^2$ (triangle 568 m by 568 m). |
| **Slopes and Drainage:** | The surface of the site has a gently rolling aspect with maximum relief of 3 m. In general, the area drains from a central crest in all directions to various lakes and a small pond located behind the coastal sand dunes. The site is generally well-drained, especially on the sandy knolls. The lower end of the swales near the coastline are imperfectly drained. |
| **Vegetative Cover:** | The sandy knolls are up to 30% bare of vegetation. The swales are completely vegetated by sedges and variety of herbs. |
| **Surface Soils:** | On the sandy knolls the active layer is 1.0 m and in the swales it is 0.5 m. The swales are underlain by 0.2 m of organically-rich silty fine sand over 0.3 m of silty fine-medium sand. The knolls are underlain by a fine-medium sand. There are polygonal trenches on the sandy knolls, and in the imperfectly drained part of the swales, these trenches reach a maximum of 0.4 m deep and 1.5 m across. |
| **Geology:** | The site is located on the remnant of a broad outwash plain. Subsequent to this deposition, ground ice within the sediments has thawed to form thermokarst depressions and lakes. Some silt has accumulated in the depression. Ground ice is present in the form of ice wedges and segregated ice lenses. Some massive ice may be present at depth. Local exposures show over 15 m of fine medium sand. |

**Access to Coast:** Direct access to the coast is possible over the partially stable dunes which are up to 60 m across and 4 m high. The beach itself is narrow, firm and sandy with a few pebbles.

**Coastal Retreat:** The coastline is retreating through wave erosion at a reported rate of 0.3 m/year.

**Marine Access:** There is no direct marine access to this site other than by small boats landing on the beach to the north. Water depths to the north and east of Tuft Point will not allow barges to offload onshore.

**Borrow:** A limited amount of silty fill is available in the swales for cover and revegetation. Sandy borrow is available from the site and beach. There are no good local sources of gravel available locally.

**Suitability:** Surface or in-ground storage is possible. Subsurface investigations will be required to locate and engineer ice-rich sediments and massive ice where present, especially for in-ground storage. There is easy winter vehicle access, but a short road will be required for summer access to prevent thaw and erosion.

Waste Storage Site **T4-34**

| | |
|---|---|
| **Location:** | **Tuft Point**, Tuktoyaktuk Peninsula<br>69.733°N, 132.500° W |
| **Maps** | Air Photo No. A22884-205<br>Hydrographic Chart No. 7663<br>NTIS 1:50,000 No. 107 C/9 |
| **I.L.A. Lands** | Yes |
| **Available Area:** | 190,000 $m^2$ (1136 m by 170 m). |
| **Slopes and Drainage:** | This rectangular-shaped site has a very gradual slope to the north with a superimposed gentle roll of maximum 3 metre relief. The site is very well-drained, even in the few small depressions along the edges of the site. The trenches forming a polygonal pattern are faint. |
| **Vegetative Cover:** | As much as 20% of surface of the site is bare of vegetation. The remainder of the surface is covered with a mixture of herbs, mainly *Dryas*. |
| **Surface Soils:** | The active layer on August 9 was 0.95 m deep. A test pit showed that 0.2 m of sandy peat overlies 0.75 m of medium sand with pebbly layers near the surface. |
| **Geology:** | The site is located on the remnant of a broad outwash plain. Subsequent to this deposition, ground ice within the sediments has thawed to form thermokarst depressions and lakes. Ground ice is present in the form of ice wedges and segregated ice lenses. Some massive ice may be present at depth. Local exposures show over 15 m of fine medium sand. |
| **Access to Coast:** | The easiest access to the site is directly to the north across gentle slopes and a narrow sandy beach. There are cultural features to be noted and avoided along this route. |

**Coastal Retreat:**

Coastal retreat due to wave erosion has been reported at an average rate of 0.3 m/year to the north of the site. Of more concern is the 1.7 m/year retreat reported along the east side of the site. This coastline is in a bay with a restricted fetch, and as a result, is difficult to explain. At another measured point along the east side of the site, an 0.8 m/year progradation has been reported. The banks on this shoreline show active sloughing.

**Marine Access:**

The narrow spit connecting Warren Point and Tuft Point has been breached since the last hydrographic survey (see air photo), allowing small boats to enter Hutchison Bay and potentially approach T4-33. Water depths are probably less than one metre, precluding barge access.

**Borrow:**

There is a very limited amount of silty fill for cover and revegetation available at site. Sandy borrow is available from the site and at beach. There are no good local sources of gravel available.

**Suitability:**

Surface or in-ground storage is possible. Subsurface investigations will be required to locate and engineer ice-rich sediments and massive ice where present, especially for in-ground storage. There is easy winter vehicle access, but a short road will be required for summer access to prevent thaw and erosion. Any access route should avoid cultural and archeological features located near the coastline.

Positioning of storage areas will have to be governed by the rate of retreat of the shoreline adjacent to the eastern edge of the site.

## Cape Dalhousie: Site L4-60

Waste Storage Site **L4-60**

| | |
|---|---|
| **Location:** | **Cape Dalhousie**, northern Tuktoyaktuk Peninsula<br>70.248° N, 129.653° W |
| **Maps** | Air Photo No. A12702-407<br>Hydrographic Chart No. 7664<br>NTIS 1:50,000 No. 107 E/2 and 107 E/7 |
| **I.L.A. Lands** | No |
| **Available Area:** | 168,000 $m^2$ (230 m by 730 m); nearby reserve areas of 275,000 $m^2$ also available. |
| **Slopes and Drainage:** | The site is nearly flat with only a slight slope to the south. Trenches at the site are commonly 0.4 m deep and 1.2 m across, with the largest trenches being 0.6 m deep and 3.5 m across, forming polygons 20 m to 30 m in diameter. The rim along the edge of the trenches can stand up to 0.4 m above the polygon centres. The site is generally well-drained, although, in the centre of a few low-centre polygons, damp areas were noted. |
| **Vegetative Cover:** | Sedge and *Dryas* cover 95% of the site. Some peaty mounds are wind eroded and free of vegetation. |
| **Surface Soils:** | The active layer was 0.7 m deep on August 9. The site contains fine medium sand overlain by 0.25 m of sandy peat. The peat layer thickens to 0.5 m in isolated areas. |
| **Geology:** | The area is underlain by a broad sandy outwash plain. The upper surface has been reworked by the wind. Peat has begun to accumulate due to poor drainage in the past. Shallow thermokarst lakes indicate that the sand contains ice lenses of varying thicknesses. |
| **Access to Coast:** | Direct access to the coast is easy, although ramps across the 3.5 m high coastal escarpements may be required. |
| **Coastal Retreat:** | The actively eroding northern coastline indicates retreat through wave erosion. No direct measurements of the coast's retreat rate have been reported, but the average retreat rate for general area is reported to be 0.5 m /year. |

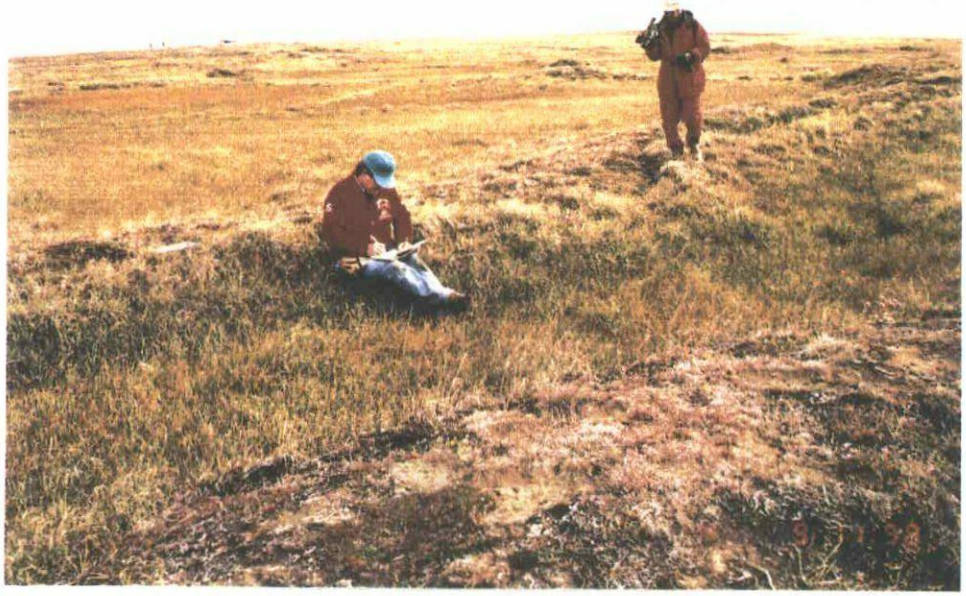
**Marine Access:** It may be possible to approach the Cape directly from the east as long as drafts to not exceed 1.5 to 1.8 m. Tidal streams between one and two knots are reported off Cape Dalhousie. Further soundings are required to confirm marine access to this site.

**Borrow:** There is a limited amount of sandy peat available for cover and revegetation. Sandy fill is available from site. The closest source of gravel is from terraces along Harrowby Bay.

**Suitability:** Surface or in-ground storage is possible. In the case of surface storage, unless the surface is leveled, storage will be restricted to separate cells in centre of polygons. Leveling of the site by filling in the trenches with elevated rims and centres would be best to keep underlying soils and waste material separate. Control of the drainage of waste material into the trenches will be required to prevent thaw and erosion. There is easy vehicle access to the area upon construction of a ramp across the steep coastal bank.

Aerial View of Site L4-60 and Cape Dalhousie from the East

Aerial View of Site L4-60 from the North



View of Site L4-60 showing elevated rims along polygons

View of the Beach at Site L4-60


Aerial View of Site T4-33 from the Northwest

View South of Shoreline near Site T4-33


Aerial View of Sites L4-34 and T4-34 from the Northeast

View North from Site T4-34

## Southeast of Cape Dalhousie: Site DR-1

Waste Storage Site **DR-1**

| | |
|---|---|
| **Location:** | **Southeast of Cape Dalhousie,** northeastern Tuktoyaktuk Peninsula<br>70.170°N, 129.573° W |
| **Maps** | Air Photo No. A12702-403<br>Hydrographic Chart No. 7664<br>NTIS 1:50,000 No. 107 E/2 |
| **I.L.A. Lands** | No |
| **Available Area:** | 230,000 $m^2$ (344 m by 688 m). |
| **Slopes and Drainage:** | The site slopes very gently toward Liverpool Bay with a gentle roll having maximum relief of 2 m. The site is well-drained. Some areas of the site have trenches up to 0.4 m deep and 1.5 m across forming polygons 8 m to 20 m in diameter. The rims occasionally stand up to 0.4 m above the centres of the polygons. |
| **Vegetative Cover:** | Sedges and *Dryas* cover 95% of site. The rare prostate willow shrub is present. Wind erosion has removed the vegetation from some of the mounds. |
| **Surface Soils:** | The active layer was 0.7 m deep on August 9. A test pit showed that the upper 0.25 m of soil consisted of medium sand and contained a large proportion of peat. |
| **Geology:** | The area is underlain by a broad sandy outwash plain. The upper surface has been reworked by the wind. Peat has begun to accumulate due to poor drainage in the past. Shallow thermokarst lakes indicate that the sand contains ice lenses of varying thicknesses. |
| **Access to Coast:** | Direct access to the coast is easy, although ramps across the 4 m high coastal escarpments may be required. Cliff-top dunes of up to 2 m high crest some of the escarpments. The beach is composed of firm fine sand and has driftwood on it. |
| **Coastal Retreat:** | Portions of the coastline are eroding and other parts are stable. This is due to the protected bay and a low rate of retreat. |

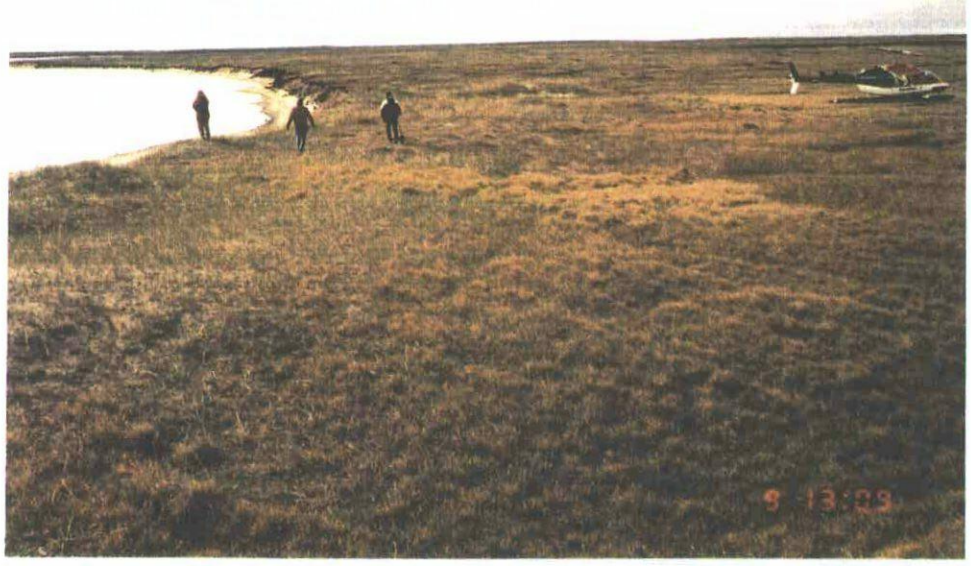
**Marine Access:** There are no reported depth measurements immediately offshore of the site. The 5 m contour is trending away from the coast at this point, indicating likely shoal water for several kilometres off the site. Assume no direct marine access is possible.

**Borrow:** There is a limited amount of sandy peat available locally for cover and revegetation. Sandy fill is available from the site and the closest source of gravel is from the terraces along Harrowby Bay.

**Suitability:** Either surface or in-ground storage is possible at this site. If surface storage is considered, waste will have to be separated from the underlying soils by leveling the area where polygons are present. This can be achieved by filling the trenches in with material from the elevated rims and polygon centres. There is easy vehicle access upon the construction of a ramp across the steep coastal bank.


Aerial View of Site DR-1 from the North


Aerial View of Site DR-1 from the East




View of Site DR-1 from the South

Pit at Site DR-1

## Johnson Bay Site DR-2

Waste Storage Site **DR-2**

| | |
|---|---|
| **Location:** | **Johnson Bay**, north side of Liverpool Bay<br>70.019°N, 129.527° W |
| **Maps** | Air Photo No. A12702-398<br>Hydrographic Chart No. 7664<br>NTIS 1:50,000 No. 107 E/2 |
| **I.L.A. Lands** | Yes |
| **Available Area:** | 210,000 $m^2$ (1340 m by 160 m); a similar reserve area of 300,000 $m^2$ is available further up Johnson Bay. |
| **Slopes and Drainage:** | The site is flat. The easterly third of the site is well-drained, whereas the remainder is only moderately well to imperfectly drained, with the exception of the low broad dune ridges that stand 1 m above the general level of the plain. Drier areas show a faint polygonal pattern, and the imperfectly drained areas show 5 m to 10 m diameter polygons outlined by 0.2 m deep and 1 m wide trenches. |
| **Vegetative Cover:** | The drier areas of the site have micro-hummocks and 15 to 20% of the area is not vegetated. Vegetation in the drier area is a mixture of sedges and herbs, primarily *Dryas;* Vegetation in the wet areas is primarily sedges. |
| **Surface Soils:** | The active layer in the drier areas was 0.6 to 0.7 m deep on August 9, and in the wet areas, 0.4 to 0.5 m deep. In the drier areas, Up to 0.35 m of sandy peat overlies a layer of fine medium sand. The wet areas are underlain by an organic silt layer exceeding 36 cm in thickness. |
| **Geology:** | The area is underlain by a broad sandy outwash plain. The upper surface has been reworked by the wind. Peat has begun to accumulate due to poor drainage in the past. The sand is over 10 m thick. Shallow thermokarst lakes indicate that the sand contains ice lenses of varying thicknesses and possibly isolated massive ice bodies. |

**Access to Coast:** Direct access is available to the spit at the entrance to Johnson Bay. The route follows the long draw in the bank to a narrow sandy beach with cobbly lag. Cliff-top dunes with a height of up to 3.5 m are present at the top of the escarpments along Johnson Bay. Direct access to Liverpool Bay is difficult because of the steep eroding 10 m high cliffs.

**Coastal Retreat:** Escarpments along Liverpool Bay are actively retreating. The coastline in this region is reported to be retreating at an average annual rate of 0.8 m/year. The coastline along Johnson Bay is retreating at slower rate.

**Marine Access:** Depths are unknown in the approaches and in the Bay itself. There is an overwashed bar paralleling the coast about 2 km off the entrance to Johnson Bay. Further soundings would be needed to confirm barge access.

**Borrow:** There is a limited amount of organic silt and peat available locally for cover and revegetation. Sand fill is available at the site. The closest source of gravel is contained in the terraces along Harrowby Bay.

**Suitability:** Either surface or in-ground storage is possible at the site. The dry area at the south end of the site is the best storage area. If in-ground storage is contemplated, a subsurface investigation should be completed to locate and engineer ice-rich sediments or massive ice where present. There is easy vehicle access from Johnson Bay.


Aerial View of Favoured Area of Site DR-2 from the East

Third Pit at Site DR-2

View of Dunes at the Edge of Site DR-2

View of the Spit at the Entrance to Johnson Bay (Access Pt. for Site DR-2)

## Pulsating Pingo: Site DR-3

## Waste Storage Site **DR-3**

| | |
|---|---|
| **Location:** | **Pulsating Pingo**, north side of Liverpool Bay |
| **Maps** | Air Photo No. A12704-101<br>Hydrographic Chart No. 7664<br>NTIS 1:50,000 No. 107 D/15 |
| **I.L.A. Lands** | Yes |
| **Available Area:** | 180,000 sq. m (858 m by 214 m). |
| **Slopes and Drainage:** | Site slopes gently toward creek at western edge, although part adjacent to Liverpool Bay slopes toward Bay for ~ 40 m. Site is well drained. |
| **Vegetative Cover:** | Up to 10% of area is bare of vegetation especially dry areas characterized by small hummocks. Area vegetated by mix of sedges, ericads, and other herbs - occasional prostrate willow. |
| **Surface Soils:** | Active layer is 0.65 m thick on August 9. Upper 0.25 m of fine medium sand contains peaty layers. |
| **Geology:** | Area, underlain by broad sandy outwash plain. Upper surface has been reworked by wind. Sands are over 12 m thick. Thermokarst indicates sands contain ice lenses of varying thicknesses and possibly massive ice bodies. |
| **Access to Coast:** | Direct access to Liverpool Bay easy via stabilized moderate 4 m high bank near creek at west end of site. |
| **Coastal Retreat:** | Escarpments along Liverpool Bay are actively retreating. The coastline in this region is reported to be retreating at an average annual rate of 0.8 m/year. |
| **Marine Access:** | Direct barge offloading is a good possibility. The 5 m contour runs close inshore along this section of the coast. The site is exposed with little shelter except from Northwesterlies. Note scattered large boulders (up to 1 m in diameter) on beach. |

**Borrow:** There is a limited amount of organic silt and peat available locally for cover and revegetation. Sand fill is available at the site. The closest source of gravel is found in the terraces along Harrowby Bay.

**Suitability:** Surface or in-ground storage possible. Subsurface investigation should be completed to locate and engineer ice-rich sediments or massive if in-ground storage contemplated. Easy winter vehicle access from Liverpool Bay, but summer access will require engineering of road across bank between beach and site.

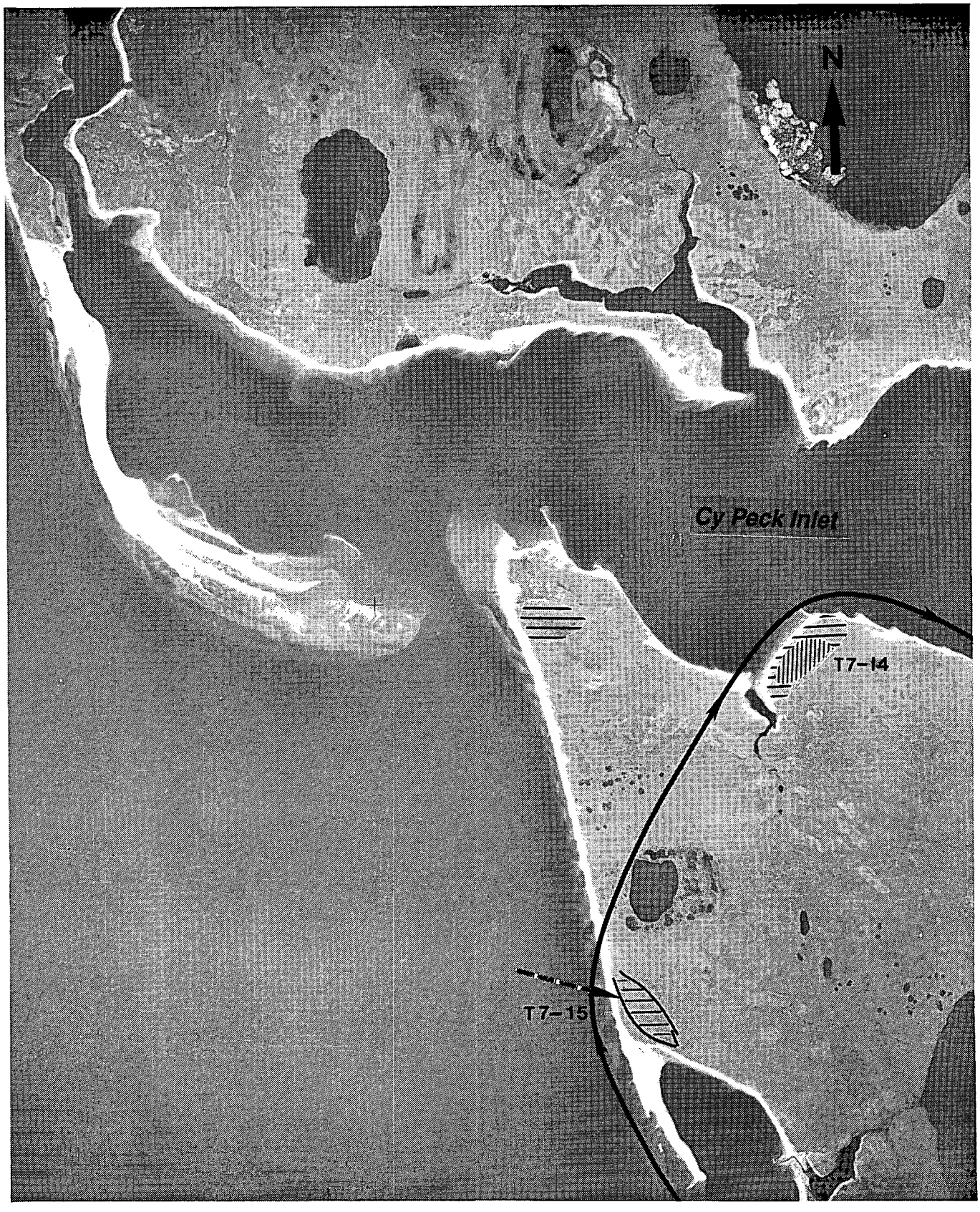

Aerial View of Site DR-3 from the Southeast Showing the Low Bank Access and the Pulsating Pingo

View of Coastline at Site DR-3 looking Northeast

Pit at Site DR-3

View of Coastal Access to Site DR-3 at the Creek Mouth

## Cy Peck Inlet: Site T7-14, T7-15



Waste Storage Site **T7-14**

| | |
|---|---|
| **Location:** | **Cy Peck Inlet**, north of Harrowby Bay<br>70.339° N, 128.060° W |
| **Maps** | Air Photo No. A12704-201<br>Hydrographic Chart No. 7664<br>NTIS 1:50,000 No. 107 E/8 |
| **I.L.A. Lands** | Yes |
| **Available Area:** | 55,000 $m^2$ (80 m by 690 m); area may be restricted by coastal setback. |
| **Slopes and Drainage:** | The site is flat, but moderately well-drained. A polygonal system of trenches up to 0.4 m deep and 1 m across with polygon diameters varying from 15 to 30 m drain toward the coast. The area inland from the site is also flat and only moderately-well to imperfectly drained. |
| **Vegetative Cover:** | Parts of site are covered completely by sedge meadows and other parts are up to 25% bare with vegetation consisting mainly of sedges and *Dryas*. The area inland from the site is completely vegetated with mainly sedges. |
| **Surface Soils:** | The active layer at the site was 0.9 m deep on August 9. A test pit showed that there is a 0.4 m layer of silt intermixed with organic layers overlying 0.5 m of medium sand. The area inland from the site probably has a thicker layer of silt over the sand layer. The silt layer will be icy if frozen. |
| **Geology:** | The region is underlain by over 6 m of medium sand of a glaciofluvial or marine origin. Although the sand may contain some excess ice in the form of lenses, massive ice is not expected to be present at the site. |
| **Access to Coast:** | Direct access to Cy Peck Inlet from the site is easy. The route follows a low stabilized bank to a small inlet west of the site. Access to the open ocean is more complicated because 1500 m of flat and poorly-drained terrain requires crossing. |

**Coastal Retreat:** Banks along Cy Peck Inlet are unvegetated indicating some erosion by wave action in spite of the restricted fetch. No rates of coastal retreat have been reported for this area.

**Marine Access:** There is insufficient water to allow barges entry into the Inlet. Only small boats drawing less than 1 m could approach the beach adjacent to the site.

**Borrow:** A limited amount of silty fill is available at the site for cover and revegetation. Sandy borrow is available at the site and on a nearby spit. The closest source of gravel is from the terraces along Harrowby Bay.

**Suitability:** Either surface or in-ground storage possible at the site, although coastal retreat rates should be determined before implementing ground storage. There is easy winter vehicle access to the site, but summer access directly from the open coast would require construction of an engineered road.

As per our photo interpretations, other moderately well-drained areas appear to be available between T7-14 and Liverpool Bay. Field examination for verification is required.

## Waste Storage Site **T7-15**

| | |
|---|---|
| **Location:** | **Cy Peck Inlet**, north of Harrowby Bay<br>70.318° N, 128.092° W |
| **Maps** | Air Photo No. A12704-201<br>Hydrographic Chart No. 7664<br>NTIS 1:50,000 No. 107 E/8 |
| **I.L.A. Lands** | Yes |
| **Available Area:** | 130,000 $m^2$ (365 m by 365 m); this area could be expanded. |
| **Slopes and Drainage:** | The site is extremely flat, and is moderately well to poorly drained with standing water in polygon trenches and low centres. |
| **Vegetative Cover:** | Sedge meadows. |
| **Surface Soils:** | Medium sands are overlain by 0.3 to 0.5 m of peat and silt. |
| **Geology:** | **See T7-14** |
| **Access to Coast:** | Direct access to the coast is easy since the banks along the coast and leading to the spit are only 2 m high. |
| **Coastal Retreat:** | No rates of coastal retreat have been reported from this area. |
| **Borrow:** | A limited amount of organic silty fill is available at the site for cover and revegetation. It may be difficult to extract sand fill from the site due to the drainage. However, sand fill is available from a nearby spit and gravel can be obtained from the terraces along Harrowby Bay. |
| **Suitability:** | Short-term surface storage is possible, but in-ground storage maybe difficult due to poor drainage. Short-term storage may be limited due to drainage disruption and thaw. There is easy winter and summer vehicle access from the spit to south; however, a short road will be required for summer access. |

View of the Pit at Site T7-31

View of Shoreline at Site T7-31 from the North

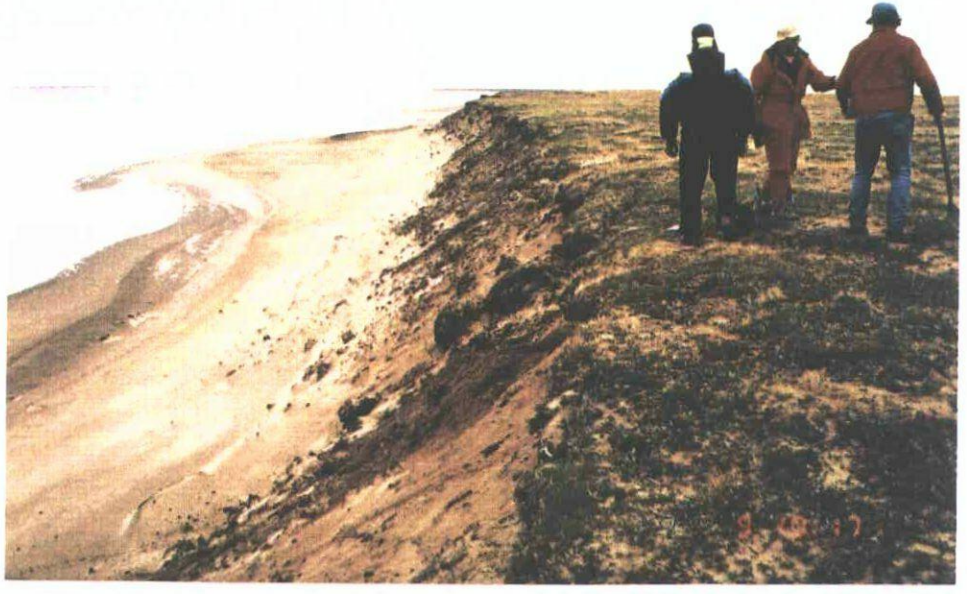
View of Cliff Exposure at Site T7-31

View of the Beach at Site T7-31 from the South

Aerial View of Site T7-14 from the West

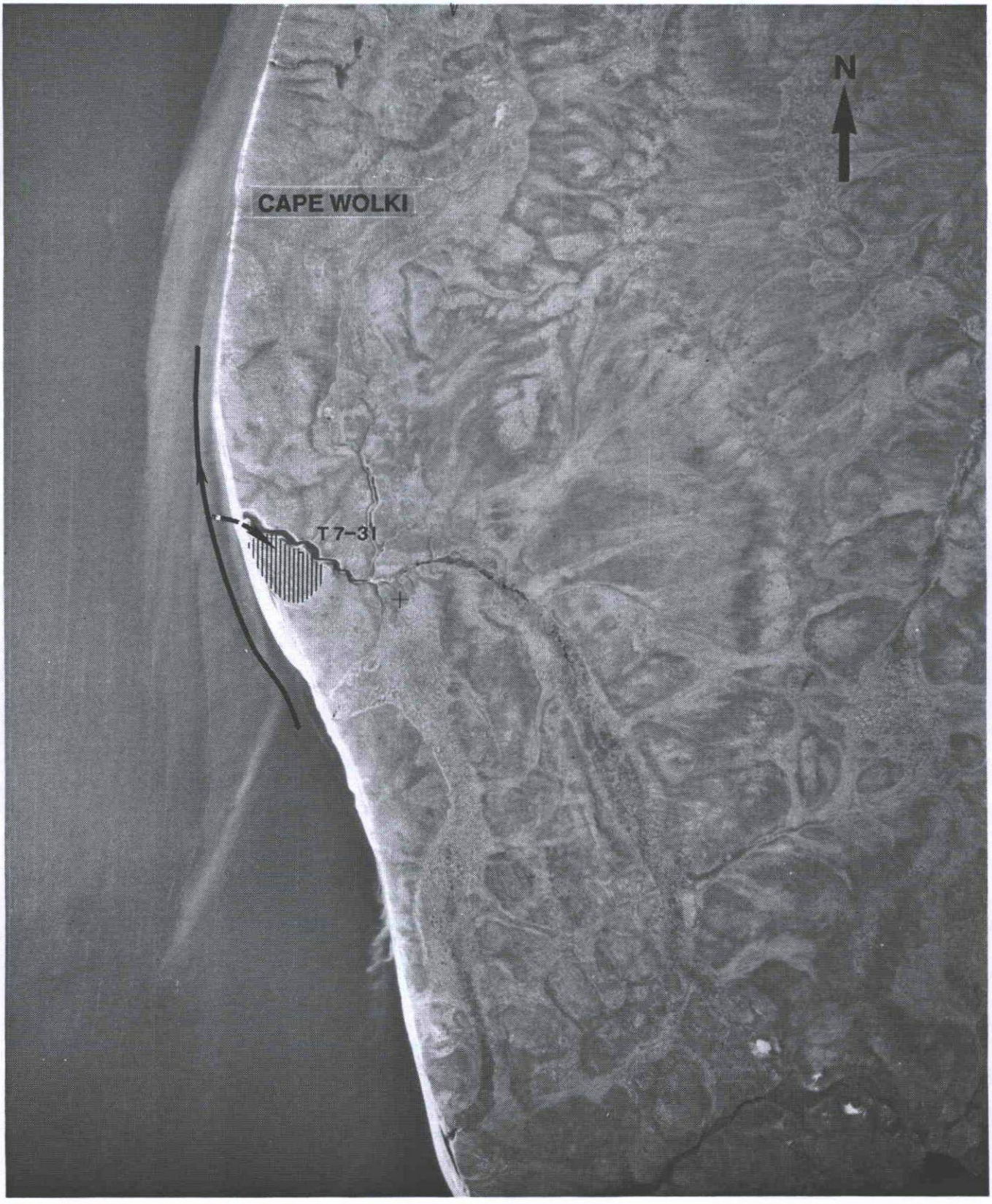
View of Site T7-14 from the First Pit

Pit at Site T7-14



View of Coastline at Site T7-14 from the Southwest

## Cape Wolki: Site T7-31



Waste Storage Site **T7-31**

| | |
|---|---|
| **Location:** | **Cape Wolki**, east side of Liverpool Bay<br>70.057° N, 128.378° W |
| **Maps** | Air Photo No. A12704-116<br>Hydrographic Chart No. 7664<br>NTIS 1:50,000 No. 107 E/1 |
| **I.L.A. Lands** | Yes |
| **Available Area:** | 200,000 sq. m (triangle, 1000 m by 400 m) |
| **Slopes and Drainage:** | Site slopes very gently toward small drowned valley to north. Surface rarely interrupted by polygonal pattern of trenches up to 0.5 m deep and 1.0 m across. Site is moderately well drained. |
| **Vegetative Cover:** | Frost boils have devegetated up to 40% of the site. Remainder covered by mixture of sedges, Ericalis, and other herbs, but predominantly shrubby willows. |
| **Surface Soils:** | Active layer is 0.6 m deep on August 9. Test pit indicates upper 0.2 m of silt contains organic layers. |
| **Geology:** | Regionally area is underlain by alluvial and marine silts and marine clays. Coastal exposure at this site indicates that over 2 m of silt with fine sand layers and pebble layers overlies marine clay. Along the coast, eroding cliffs indicate unconsolidated sediments contain some ice in form of ice lenses, but general absence of massive ice other than ice wedges. |
| **Access to Coast:** | Direct access to coast along most of site is difficult due to 8 m high steep banks, but adjacent drowned valley banks are less steep and only 4 m high allowing easy access. Site is bordered by sandy tidal flat up to 35 m across and barrier gravelly beach up to 50 m across. Barrier beach is over 1 m high. |
| **Coastal Retreat:** | Banks adjacent to the site are stabilized; possibly because of barrier beach. |

**Marine Access:** There are no reported soundings nearshore but the configuration of the coast and limited offshore depths indicate that there may be sufficient water for barges to approach the beach. This site is highly exposed to winds from the NW.

**Borrow:** Site has ample silt for cover and revegetation. Sand and gravel are available from barrier beach adjacent site. Gravel is also present at top of banks north of drowned valley. Larger deposits of gravel are present in terraces along Harrowby Bay to north.

**Suitability:** Surface or in-ground storage possible, although care will be necessary in excavating, thawing and draining site. Easy winter and summer access from coast is possible. Short slope up from barrier beach will require engineering to prevent excessive erosion.

# APPENDIX D

Attendees at Northwest Territories Project Meetings, August 1992

## Meeting in Inuvik, N.W.T.: August 13, 1992

| Name | Organization | Community |
|---|---|---|
| Ron Allen | Department of Fisheries and Oceans | Inuvik, N.W.T. |
| Billy Day | Inuvik Hunter and Trappers Committee | Inuvik, N.W.T. |
| Alex Aviugana | Fisheries Joint Management Committee | Inuvik, N.W.T. |
| David Dickins | DF Dickins Associates Ltd. | Vancouver, B.C. |
| Vern Rampton | Terrain Analysis and Mapping Services Ltd. | Carp, Ontario |
| Bruce Hanbidge | Wildlife Management Advisory Council | Inuvik, N.W.T. |
| Charles Klengenberg | Inuvaluit Lands Administration | Tuktoyaktuk, N.W.T. |
| Veryl Gruben | Tuktoyaktuk Hunter and Trappers Committee | Tuktoyaktuk, N.W.T. |
| Bill Smith | Canadian Parks Service | Inuvik, N.W.T. |
| Renie Arey | Aklavik Hunters and Trappers Committee | Aklavik, N.W.T. |
| Don Aviugana | Aklavik Hunters and Trappers Committee | Aklavik, N.W.T. |
| Marshall Netherwood | Environmental Impact Screening Committee | Inuvik, N.W.T. |
| Laura Johnston | Environment Canada | Yellowknife, N.W.T. |
| David Tilden | Environment Canada | Yellowknife, N.W.T. |
| Stephen Charlie | Environment Canada | Inuvik, N.W.T. |
| Jane Bicknell | Inuvaluit Lands Administration | Inuvik, N.W.T. |

## Meeting in Yellowknife, N.W.T.: August 17, 1992

| Name | Organization |
|---|---|
| Art Boutilier | Department of Indian Affairs and Northern Development |
| Bob Ferguson | Canadian Wildlife Service |
| Laura Johnston | Environment Canada |
| David Tilden | Environment Canada |
| Tod Burlingame | Energy, Mines, and Petroleum Resources, Government of the N.W.T. |